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TEST ON A 400 K W TURBO-ALTERNATOR AND AUXILIARIES

by

EDWARD HERMAN SCHROEDER

ANDREW HENRY MARTIN

and

JOHN RICHARD SHEA

A Thesis submitted for the Degree of

Bachelor of Science in

Electrical Engineering

University of Wisconsin

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INTRODUCTION.

The choice of type of prime mover in a steam power plant between reciprocating engines and steam turbines is merely a matter of opinion; the reciprocating engine is the older of the two and is entirely out of the experimental class, whereas the turbine, at the present time, is right in the stage of development.

The principal advantages of the turbine over the reciprocating engine are as follows:- (1) the turbine has a uniform angular velocity and alternators operate more satisfactorily in parallel when driven by turbines; (2) the turbine exhaust steam contains no cylinder oil and hence the condensed steam from the turbine can be fed directly to the boiler or a feed water heater; (3) with a turbine installation the generator is almost always direct-connected to the turbine and in consequence of this fact, troubles with belts or other connectors are eliminated and the unit is more compact and occupies less floor space. Other advantages claimed for the turbine, such as, less steam consumption per unit capacity, ability to withstand continuous operation without shut-down, and ability to use

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high temperature super-heated steam, are in many instances, overrated.

Turbines operate best on a rather high vacuum and large units are seldom run non-consensing. Reciprocating engines operate satisfactorily without a vacuum.

The best turbines compare very favorably with the best reciprocating engines and it would be improper, at the present time, to state that in the future either one of the two could shut out the other.

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TESTS PERFORMED.

1. A Twenty-four Hour Test on a 400 K. W. 3-phase Westinghouse Turbo Generator, including a Twenty-four Hour Boiler Test on a 500 H. P. Water Tube Stirling Boiler.

2. A Twelve-hour Boiler Test on the 500 H. P. Water Tube Stirling Boiler.

3. A Series of Tests on a 40 K. W. Northern Terry Turbo-Exciter Unit.

   (a) A Test to Determine the Behavior of the Northern-Terry Exciter Unit at Various Loads.

   (b) A Test to Determine the Behavior of Exciter Unit after larger Nozzles had been placed in the Turbine.

   (c) A Test to determine the Speed Regulation of the Turbine at Various Loads and the Effect of sudden Changes of Load upon the Turbine Speed.

   (d) A Test to determine the full Performance of the Exciter Turbine, including the Steam Pressure upon the Blades of the Turbine at Various Loads.

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LIST OF PRINCIPAL MACHINES AND UNITS IN THE PLANT IN WHICH TEST ON 400 K. W. WESTINGHOUSE PARSONS TURBO-ALTERNATOR WAS MADE.

Two Wickes Water Tube Boilers each 300 H. P. capacity.

One Stirling Water Tube Boiler of 500 H. P. capacity.

One 400 K. W. Westinghouse Parsons Turbo Alternator. 2300 v. 3-phase. 60 cycles.

One 25 K. W. 120 volt Exciter Unit direct-connected to an 8 in. by 10 in. Ideal Engine.

Two 300 K. W. 2300 v. 60 cycles, 3-phase to 575 D. C. Motor Generator sets.

One 280 H. P. Gas Engine, 3 cylinders, belted to a 200 K. W. 550 D. C. Generator.

One 280 H. P. Gas Engine, 3 cylinders, belted to a 120 K. W. 2300 volt, single-phase 60 cycle Alternator, and to a 150 K. W. 550 D. C. Generator.

One 125 H. P. 3 cylinder Gas Engine belted to a 75 K. W. 550 v. D. C. Generator.

One 500 v. D. C. Motor direct-connected to a 58 v. D. C. Booster Generator.

One 500 K. W. Allis Chalmers Turbo Alternator of the Parsons type 2300 v. 60 cycles, 3-phase.

A Battery of about 280 chloride Accumulator Cells operated in connection with the street-car power circuit.

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This plant operates in connection with a gas plant located east of it and also in connection with an auxiliary steam station, located on Williamson Street, which is operated only when the station wherein the test was made is unable to carry the load due to heavy overload, breakdown, or shutdown.

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GENERAL CONDITIONS.

The 400 K. W. Westinghouse Parsons Turbo Alternator which was tested is not operated throughout the whole twenty-four hours of the day when the plant is running under normal operating conditions. It is used as a reserve capacity to help carry the peak load which comes on from 4:30 P. M. to 5:30 P. M., depending upon the nature of the weather and the season of the year, and lasts usually until about twelve o'clock at midnight. A 500 K. W. Turbo Alternator takes care of the load during the hours of daylight and after midnight. A 500 H. P. Water Tube Stirling Boiler supplies the steam for this 500 K. W. unit, while it runs alone.

At about 3:30 P. M. one, or both, of two 300 H. P. Wickes Boilers is fired up so that they may be cut into the main steam header as soon as the peak load comes on. As soon as it becomes dusk the various lighting circuits are loaded and the load increases very rapidly. It is then that the Wickes boilers are cut into the main header and the 400 K. W. 2300 v. 3-phase Westinghouse Turbo Alternator is started and synchronized with and operated in parallel with the 500 K. W. 3 phase Alternator. The two machines are operated in parallel

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till about midnight when the load again drops down, the Westinghouse 400 K. W. unit is shut down, and the 500 K. W. unit continue to operate carrying the load alone. The units just discussed supply power to two motor generator sets which supply 500 v. D. C. power to the Railway and Commercial Power circuits, and to the various arc lighting, and incandescent lighting circuits of a city having a population of about 30,000 people. In view of the fact that the city would be left without power or light in case of a shut down of the plant extreme care was necessary in carrying out this test.

All the steam driven apparatus of the plant, with perhaps the exception of some of the boiler feed pumps takes its steam from the main steam header. Besides this, steam for the gas works is drawn through a reduction valve, and steam for heating the engine room is drawn from the main header. There are no valves located in the header proper, but valves are used for each boiler so that it may be cut out if desirable.

The Exhaust steam from the 500 K. W. Turbine is condensed by a 2000 sq. ft. Alberger Surface Condenser which holds a vacuum of about 27 inches of mercury almost constantly. The 400 K. W. Westinghouse Unit tested

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exhausts into a special type of jet condenser designed by Mr. H. L. Doherty. Vacuum is kept on this condenser by a Stillwell, Bierce & Smith Vaile Co. Dry vacuum pump. A centrifugal pump direct-connected to a 20 H. P. 550 v. D. C. Northern vertical shaft motor draws the circulating water and condensed steam, or cooling water from the jet condenser. The centrifugal pump merely exhausts the water from the condenser, and the vacuum causes the atmospheric pressure to force the cooling water into the condenser.

The water used for boiler feed condensing and cooling water is pumped from Lake Monona by a centrifugal pump geared to a 50 H. P. 3-phase 2300 v. induction motor which discharges the water through a 20" main into the water seal of a 60,000 cu. ft. gas holder located near the plant. The water is then drawn from this holder as it is needed.

During regular operation all exhaust steam from theexciter unit, dry vacuum pumps, wet vacuum pumps and boiler feed pumps is discharged through a 10" pipe into a Cochrane 1500 H. P. Feed water heater.

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The Twenty-Four Hour Test on the 400 K. W. 2300 v. Westinghouse Turbo Alternator, Including a Twenty-Four Hour Boiler Test on a 500 H. P. Water Tube Stirling Boiler.

It was decided to run a complete plant test including the 400 K. W. Alternator. The question at once arose as to the best method of proceeding. To conduct this test several things had to be kept in mind; first and most important, nothing could be done which would create a likelihood of the plant's being forced to shut down during the test; second, there was no way in which to confine the steam consumption of the turbine to any of the boilers alone, due to the fact that there is no valve in the main header between the boilers. This meant that the 500 K. W. unit had to be closed down during the test.

The Westinghouse Turbine exhausts into the jet condenser. This made the direct measuring or weighing of the exhaust steam practically impossible due to the large quantities of water involved and the limited apparatus to be had. To get around this difficulty several methods were suggested. Most of them were such as involved the metering of the cooling water entering the condenser and the total quantity of water leaving the condenser by means of the

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pitot tube, venture meter or similar methods. All data available on such measurements showed that individual observations might give results which were in error by about 2 or 3% from the actual amounts of water measured. As the total steam condensed is only from 8 to 12% of the total water discharged from a jet condenser by weight, it is readily seen why such methods of measuring the steam consumption of the turbine would be unsatisfactory.

It was finally decided to determine the steam consumption of the turbine in the following manner: - All of the boiler feed water was to be accurately weighed, and all the condensed steam from the auxiliaries and traps was to be weighed. Then to obtain the weight of the condensed steam from the turbine subtract the amount of auxiliary condensed steam and trap steam from the total weight of boiler feed water for the period of time in consideration. To attain this end it was found necessary to install and use three auxiliary condensers.

Duration of the Test 1 A. M., Mar. 28, till 1 A. M., Mar. 29, 1909.

<u>Object of the Test</u>.

The object of the test was to determine the performance of the 400 K. W. 2300 v. Westinghouse Parsons

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Turbo Alternator when under actual operation and also to determine the efficiency of the plant.

A general outline of the test as actually conducted will now be given.

All instruments, gauges, thermometers and all measuring apparatus used during this test were first calibrated and when corrections were found to be necessary, calibration curves were plotted which are all recorded in this thesis.

Operating conditions of the plant had to be changed somewhat from ordinary normal conditions due to things already mentioned. The time selected for running the test was from Sunday at 12:00 A. M. till on Monday at 12:00 A. M. This was in fact the only day of the week upon which the Westinghouse Turbine with the aid of another small plant would be able to carry the whole load for a period of 24 hours. The date selected was Mar. 28, 1909. During the test the 500 K. W. unit was shut down. The steam supply for the Gas Works was cut off and a boiler at the gas plant furnished the necessary steam for the gas manufacture. The steam for the heating of the engine room was shut off because heating was found. to be unnecessary. Some of the steam traps were shut off while

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the pipe connections for the others were broken so that the water discharged from them could be caught in tubs and weighed. The feed water heater before mentioned was cut out altogether. The exhaust pipes from all the auxiliary steam driven apparatus were by-passed so as to make it possible to condense the exhaust steam in the auxiliary condensers which were installed.

The following steam driven apparatus was in operation during the 24 hour test, - The 400 K. W. 2300 v. 3-phase Westinghouse Parsons Turbo Alternator, a 40 K. W. 125 v. Northern-Terry Turbo Exciter unit, a Stillwell Bierce and Smith Vaile Co. dry vacuum pump and two feed water pumps.

Auxiliary Condensers.

The condensers installed for condensing the exhaust steam from the auxiliaries were as follows:-

One 40 H. P. Wheeler condenser used to condense the steam from the 40 K. W. Northern Terry Turbo Exciter unit, a condenser consisting of sections of pipe joined by L-couplings placed in a tank surrounded with cooling water, which was used to condense the exhaust from the two feed water pumps, and an old boiler which had been rigged up to be used as a condenser was used to condense

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the exhaust from the dry vacuum pump. A platform scale and tubs were placed at each of these condensers for weighing the condensed steam. Provision was also made in each case by using suitable valves so that the condenser could be cut out and the exhaust turned back into the feed water heater, upon any accident which would disable the condenser.

Boiler Feed Water.

All boiler feed was taken from the water expelled from the larger jet condenser of the 400 K. W. Turbine, and forced through the condenser for the vacuum pump as cooling water so as to heat it slightly before feeding it into the boiler. The boiler used was the 500 H. P. Water tube Stirling type. A platform was erected near the boiler, upon which were mounted two platform scales of 2000# capacity, each of which had placed upon it a 1500# weighing tank with a 3-1/2" rapid opening gate valve. One feed water pump was connected up with suitable piping and valves and used to pump the feed water up into these weighing tanks. The water was weighed and then allowed to flow by gravity into a 2500# hot well near at hand and below them. The other and smaller feed water pump was used to pump the feed water out of the hot well and force it into the boiler. The water level in the boiler was kept constant and the

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amount of boiler feed checked up for each hour run during the test.

Coal, Firing and Ash.

The coal used was a fairly good grade of soft coal. All coal fired during the test was weighed. The grates were cleaned just before the test was started and all ash removed from the ash pit. All ash removed during the whole test was weighed and its weight recorded. Alternate hand firing was employed and the fires were kept as uniform as possible. At the end of the test the grates were cleaned and all the ash weighed. The fires were drawn at about 6 o'clock, at 12 o'clock and at about 6 o'clock in the evening during the test. The amounts of coal were not checked up for regular intervals due to some difficulty in bringing in the coal, but the total amount consumed during the 24 hours was recorded.

Flue Gas, Temperature of Stack, and Draft.

A sample of the flue gas was taken every hour and analyzed for $C\,O_2$, O_2 and $C\,O$ by means of the Orset Apparatus.

The temperature of the stack was measured every hour by a calibrated thermo couple placed in the stack over the boiler. The chimney draft was read by means of a kerosene

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differential draft gauge placed in the breech of the furnace, calibrated to read in inches and hundredths of inches of water.

The quality of steam was determined by means of a throttling calorimeter placed in the steam pipe directly above the boiler. The gauge pressure at the boiler was measured by a calibrated gauge placed on the steam pipe directly above the boiler.

Data Taken at the Turbine.

The Revolution made by the turbine was recorded by a stroke counter which counted the strokes made by the oil pump. This stroke counter was read every fifteen minutes and the readings recorded. The ratio between the strokes of the oil pump and the revolutions of the turbine was determined as 1 : 21. From this the Revolutions per minute were determined.

The gauge pressure was taken at the steam feed pipe to the turbine every fifteen minutes by a calibrated gauge, which was found to be correct as close as it could be read.

The power input into the motor driving the condenser water pump was measured by Weston D. C. Ammeter #6010, 0 to 25 amps. each of which had been previously

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calibrated. Readings were taken every fifteen minutes.

The vacuum on the exhaust of the turbine was measured by a mercury tube which read inches of mercury below atmospheric pressure.

The amount of oil cooling water was measured by a water meter connected in the supply pipe just at the base of the turbine.

A water meter had also been connected in to measure the gland water, but this meter did not work due to the very small amount of water passing through it to the sealing glands on the turbine.

The temperature of the condensing water was taken as it entered the condenser and also as it left the condenser.

Auxiliary Condensed Steam, and Traps.

All the auxiliary steam was condensed by the condensers installed for that purpose, and the condensed steam from each condenser weighed and recorded every fifteen minutes, so as to enable one to check the steam consumption of the turbine every hour.

The steam trap connected to the main steam header blew off on an average of once every hour. For a time this water discharged was weighed with considerable

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difficulty in catching the water, but it was found that this amount of water averaged, with the correction for a slight leakage from the hot well to about 50# or nearly 50# per hour. Thus this amount was assumed as 50# per hour and classed under Trap water in the log recorded in this paper.

<u>Steam Consumption of the Turbine</u>.

The total boiler feed was checked up each hour. Subtracting the total auxiliary condensed steam and trap water from the total boiler feed for any given period of time, gives the steam consumption for the turbine for that period.

Theoretically this sounds very well, but due to the fact that a matter of 2000# or 4000# of water makes a very slight difference in the water level of the boiler, in fact so slight that it is scarecely noticeable when the boiler is in operation; all sorts of absurd results as regards the steam consumption of the turbine per K. W. Hr. may be obtained when only a short period of time is taken into consideration. It had been intended to find the steam consumption per K. W. Hr. for the turbine at various loads, but due to the facts just mentioned this was abandoned, and the steam consumption per Av. K. W.

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Hr. found taking full twelve hour periods into consideration.

The Regular Switch Board and Instruments.

The switch used on the Turbo generator is an oil contact breaking switch so arranged that the bus bars, of which there are three, of the generator may be connected in parallel with the other generator a 500 K. W. Alternator.

The switch board contains two potential transformers, two current transformers connected similarly to those used to measure the power in the test. The secondaries of these transformers are connected to a three-phase indicating wattmeter, made by the General Electric Co. and calibrated so as to read the Kilo watt output of the Alternator directly.

The switch board also contains an ammeter which is placed in the secondary of a current transformer and calibrated so as to read the current in the primary directly.

Plugs are also provided so that any phase of the Alternator may be connected to the common switch board voltmeter.

Plugs for synchronizing are also found on the switch board.

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Method of Measuring the Power Output of the 400 K. W. 2300 v. Westinghouse-Parsons-Turbo Alternator.

The Regular Two Wattmeter Method of measuring the power output of the Alternator was used with all instruments in the secondary circuits of potential and series transformers as shown by the plate Diagrams of connections.

In the regular log of data W_1 represents one of the wattmeter readings and W_2 the other wattmeter reading. The instrument transformers were calibrated as discussed in the calibrations of instruments. The curves showing the relation between wattmeter corrected readings and $\frac{\text{Actual Primary Watts}}{\text{True Secondary Watts}} = K$ was obtained from the results of the calibration data, and the curves recorded.

V_1, V_2 and A_1, A_2 correspond to the corrected readings of the instruments having the same letter on the diagram.

The Field Current and the E. M. F. impressed across the exciting field of the Alternator were measured by D. C. calibrated instruments.

The exciting current is designated by I_F and E. M. F. across the field coils as E_F on the tabulated data.

The electrical Instruments were read every two

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minutes and recorded.

All readings were corrected and the averages for each half hour period taken and the actual values of the Primary power computed from these.

Total Power - $(K_1 W_1 + K_2 W_2)$

K_1 and K_2 were taken from the curve.

<u>Signalling to Men to take Data</u>.

A system of bells was installed, which was controlled from the main instrument table for signalling to the men when data was to be read. Readings were taken every 15 minutes. Two short rings were given 15 sec. before the time of reading and one long ring was given as the signal to read.

<u>Proximate Analysis of Coal and Heating. Value of Coal</u>.

A Proximate Analysis of coal was made according to the method given in Carpenter[1] of a sample which was gradually accumulated during the run from the coal fired.

A sample of ash was also taken and analyzed for carbon and earthy matter.

The heating value of the coal was determined by means of a Parr Calorimeter.

1 Carpenter's "Experimental Engineering."

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24-HOUR TEST.
FLUE GAS.

Time AM	Chimney Draft	% CO_2	% O_2	% CO	WT. of Coal #	WT. of Ash #
1:00	0.68"	6.%	14.0	0.5	584	
1:15	0.69				525	
1:30	0.68				520	
1:45	0.68				510	
2:00	0.69	6.0	14.0	1.0	505	
2:15	0.73				509	
2:30	0.68				510	
2:45	0.77				509	
3:00	0.67	4.6	13.6	0.1	501	
3:15	0.66					
3:30	0.68				515	195
3:45	0.69				522	186
4:00	0.67	4.0	13.9	0.1		159
					505	
4:15	0.61					205
4:30	0.67					305
4:45	0.40				553	276
5:00	0.47	2.4	11.0	1.0	551	
5:15	0.59				500	
5:30	0.76				500	
5:45	0.55				240	
6:00	0.55	4.6	12.4	0.65	200	
6:15	0.50	6.8	12.0	0.3	312	
6:30	0.40				200	
6:45	0.51					
7:00	0.52	4.6	12.4	.65		

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24-HOUR TEST - Continued.
FLUE GAS.

Time AM	Chimney Draft	% CO_2	% O_2	% CO	WT. of Coal #	WT. of Ash #
7:15	0.61				312	
7:30	0.60				217	
7:45	0.61				334	
8:00	0.62	4.2	12	0.3	2310	
8:15	0.65					
8:30	0.62					
8:45	0.63					
9:00	0.63	3.8	12.4	0.4		
9:15	0.62					
9:30	0.63					
9:45	0.64				2500	
10:00	0.62	4.00	12.3	0.3		
10:15	0.63					
10:30	0.64					
10:45	0.63				2550	
11:00	0.64	4.16	12.2	0.2	2170	
11:15	0.64					
11:30	0.63				2440	
11:45	0.65					
12:00	0.66	5.00	13.1	0.3		
12:15 PM	0.67				2660	
12:30	0.66					
12:45	0.63					
1:00	0.65	7.00	12.5	0.4		

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24-HOUR TEST - Continued.
FLUE GAS.

Time PM	Chimney Draft	% CO_2	% O_2	% CO	WT. of Coal #	WT. of Ash #
1:15	0.68				2400	
1:30	0.65					
1:45	0.66				2478	
2:00	0.69	6.0	12.1	0.5		240
2:15	0.69				2530	358
2:30	0.70					
2:45	0.69				2528	
3:00	0.67	4.8	14.0	0.4		200
3:15	0.68					
3:30	0.71					334
3:45	0.69					
4:00	0.71	4.9	13.1	0.3		
4:15	0.62					
4:30	0.67					
4:45	0.61					
5:00	0.63	6.6	12.0	0.59	2600	
5:15	0.60					
5:30	0.50					
5:45	0.50					
6:00	0.52	6.6	12.0	0.6	2624	
6:15	0.53					
6:30	0.52					
6:45	0.56					
7:00	0.34	6.8	10.8	0.7		

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24-HOUR TEST - Continued.

FLUE GAS.

Time PM	Chimney Draft "of H_2O	% CO_2	% O_2	% CO	WT. of Coal #	WT. of Ash #
7:15	0.27					
7:30	0.45					
7:45	0.31					
8:00	0.33	8.0	12.0	0.0		
8:15	0.65					
8:30	0.65					
8:45	0.66					
9:00	0.65	6.9	12.4	0.1		
9:15	0.65					
9:30	0.67					
9:45	0.67					
10:00	0.66	6.5	11.9	0.1		
10:15	0.65					
10:30	0.65					
10:45	0.64					
11:00	0.61	7.4	12.0	0.0		
11:15	0.62					
11:30	0.64					
11:45	0.64					
12:00	0.64	6.7	11.0	0.3		
12:15	0.63					
12:30	0.62					545
12:45	0.63					
1:00						
Totals					39,864	2940
Av.	0.642	5.28	12.3	0.396		

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STACK TEMPERATURES DURING 24-HOUR TEST.

Time	STACK TEMP. M. Volts	Temp. °F	Time	STACK TEMP. M. Volts	Temp. °F
AM					
1:00	11	410	10:00	11.2	415
1:30	11.5	426	10:30	11.6	430
2:00	11.2	415	11:00	12.	442
2:30	11.8	438	11:30	12.	442
3:00	12.	442	12:00	12.	442
3:30	12.	442	12:30	12.2	450
4:00	12.	442	1:00	12.2	450
4:30	11.8	438	1:30	12.4	460
5:00	12.	442	2:00	12.4	460
5:30	12.4	460	2:30	12.2	450
6:00	12.4	460	3:00	12.2	450
6:30	12.	442	3:30	12.4	460
7:00	12.	442	4:00	12.2	450
7:30	12.	442	4:30	12.2	450
8:00	12.	442	5:00	12.	442
8:30	11.8	438	5:30	12	442
9:00	11.5	426	6:00	12.2	442
9:30	11.5	426	6:30	12.1	446

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STACK TEMPERATURES DURING 24-HOUR TEST - **Continued.**

STACK TEMP. Time	M. Volts	STACK TEMP. Temp. ° F
P.M.		
7:00	11.8	438
7:30	12.	442
8:00	12.2	450
8:30	12.4	460
9:00	12.4	460
9:30	12.3	455
10:00	12.2	450
10:30	12.	442
11:00	12.	442
11:30	12.2	450
12:00	12.2	450
12:30	12.	442
1:00	12.	442
AV.		443.5

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CALORIMETER DATA AND QUALITY OF THE STEAM.

BAROMETER PRESSURE = 28.565" of MERCURY.

CALORIMETER AT THE TURBINE					CALORIMETER AT THE BOILER			
Gauge Press. #/in^2	Corrected Manom. Press: "H_g	Calorimeter Temp.	% Dry Steam	Time AM	Gauge Press. #/in^2	Corrected Manom. Press. "H_g	Calorimeter Temp.	% Dry Steam
145	6.4	276 F	98.1	1:00	145	1.6	275	98.2
147	6.0	276	98.05	2:00	149	1.8	276	98.1
150	6.7	272	97.75	3:00	150	1.9	271	97.7
151	6.6	270	97.7	4:00	145	2.5	268	97.8
150	6.6	270	97.8	5:00	148	2.3	271	98.0
145	7.0	280	98.2	6:00	150	2.2	275	98.1
145	6.8	280	98.6	7:00	149	2.2	284	98.7
140	6.5	278	98.3	8:00	148	2.5	280	98.3
140	6.6	276	98.1	9:00	146	2.2	277	98.25
145	6.9	278	98.2	10:00	150	2.2	274	98.0
139	6.4	272	98.0	11:00	145	2.0	277	98.35
145	6.6	278	98.2	12:00	145	2.0	276	98.2
142	6.9	274	97.9	1:00	153	2.1	272	98.0
146	6.4	272	98.0	2:00	148	2.3	272	98.05
141	5.3	277	98.3	3:00	147	2.4	276	98.3
137	5.6	276	98.4	4:00	148	2.4	278	98.25
141	6.1	279	98.25	5:00	146	2.3	276	98.6
143	5.5	273	97.9	6:00	143	2.0	272	97.9
140	5.9	276	98.2	7:00	147	2.1	275	98.3
144	6.3	279	98.1	8:00	151	2.2	271	98.3
145	6.5	275	98.05	9:00	147.5	2.1	275	98.1
140	6.4	278	98.2	10:00	148.5	2.1	280	98.3
146	6.2	278	98.2	11:00	146.5	2.1	272	98.2
149	6.2	277	98.1	12:00	149.0	2.2	277	98.2
145	6.2	278	98.2	1:00	145.0	2.0	279	98.4
			Av. 98.108%		Av. 147.5 #/in^2			

$$\% \text{ Dryness} = X = \frac{H_a - .48\,(t_s - t_a) - h_b}{L_b} \times 100$$

RESULTS OF 24-HOUR BOILER TEST.

The name of the plant at which this test was made is withheld by request.

Test made by Schroeder, Shea, and Martin, students of the University of Wisconsin, on a 500 H. P. water tube Stirling Boiler, to determine the behavior of the boiler under the conditions of operation.

Conditions.

The conditions were not exactly the same as those found in most boiler tests. The fires were not pulled immediately before starting the test, but at some time about 1 hour before the test was started. An endeavor was made to keep the firing as uniform as possible. The water level in the boiler was kept as nearly constant as possible. Checks were made on the amount of boiler feed every hour. The fires were pulled again 1 hour before the test was ended and all the ash removed, thus ending the test with conditions about the same as they were at the start. The fuel used was a medium grade of soft coal. The furnace was of the ordinary horizontal grate type. The method of firing was the alternate hand firing.

Barometric Pressure = 28.565" of Mercury.

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DATA AND RESULTS OF 24-HOUR BOILER TEST.

1.	Date of Trial - Mar. 28, 1909.	
2.	Duration of Trial - 1:00 A. M., Mar. 28, 1909, to 1:00 A. M., Mar. 29, 1909. Time 24 hours.	
	DIMENSIONS.	
3.	Grate surface, Area	88 sq. ft.
4.	Height of Furnace	
5.	Approximate width of air space	
6.	Proportion of air space to whole grate surface	
7.	Water-heating surface	503 sq. ft.
8.	Super-heating surface	
9.	Ratio of water-heating surface to grate surface	56.16 to 1
10.	Ratio of minimum draft area to grate surface	
	AVERAGE PRESSURES.	
11.	Steam pressure by gauge	147.5 #/in^2
12.	Force of draft in breach of furnace	0.642" of water.
13.	Force of draft in Ash pit	
14.	Force of draft in furnace over grates	

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DATA AND RESULTS OF 24-HOUR BOILER TEST.- Continued.

AVERAGE TEMPERATURES.

15.	Of external air	$47^{\circ}F$
16.	Of Fire-room	$59^{\circ}F$
17.	Of steam	$363.9^{\circ}F$
18.	Of feed water entering heater	
19.	Of feed water entering economizer	
20.	Of feed water entering boiler	$102.4^{\circ}F$
21.	Of escaping gases from boiler	$443.5^{\circ}F$
22.	Of	

FUEL

23.	Size and condition. Rather large, but broken to sizes about the size of two fists before firing.	
24		
25.	Weight of coal as fired total 24 hrs	39,864.00 lbs.
26.	Per cent of moisture in coal	2%
27.	Total weight of dry coal consumed, 24 hrs	39,069.2 lbs.
28.	Total weight of ash and refuse, 24 hrs	2940 lbs.

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DATA AND RESULTS OF 24-HOUR BOILER TEST - Continued.

	FUEL - Continued.		
29.	Quality of ash and refuse, dry		
30.	Total combustible consumed, 24 hrs	36,129.2 lbs.	
31.	Percentage of ash and refuse in dry coal	7.52%	
	PROXIMATE ANALYSIS OF COAL.		
		Of Coal	Of Combustible.
32.	Fixed carbon	62.2%	67.6%
33.	Volatile matter	29.8%	32.4%
34.	Moisture	2%	
35.	Ash	7%	
36.	Of sulphur, Omitted		
	ULTIMATE ANALYSIS OF COAL.		
	Items 37, 38, 39, 40, 41 and 43 Omitted.		
	ANALYSIS OF ASH AND REFUSE.		
44.	Carbon	38%	
45.	Earthy matter	62%	

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DATA AND RESULTS OF 24-HOUR BOILER TEST - Continued.

FUEL PER HOUR.

46.	Dry coal consumed per hour........................	1627.88 lbs.
47.	Combustible consumed per hour.....................	1505.38 lbs.
48.	Dry coal per sq. ft. of grate area/hr...............	16.28 lbs.
49.	Combustible per sq. ft. of heating surface of boiler per hour..	0.299 lbs.

CALORIFIC VALUE OF FUEL.

49-1/2.	Calorific value of 1 lb. of coal as fired........	13,185 B. T. U
50.	Calorific value of 1 lb. dry coal by Pan Calorimeter	13,445 B. T. U
51.	Calorific value of 1 lb. of combustible by Pan Cal...	14,331 B. T. U
	Items 52 and 53 Omitted.	

QUALITY OF STEAM.

54.	Percentage of Moisture in steam..........................	1.78 %
55.	Degrees of super-heating - (No superheat)	
56.	Quality of steam = X = ...	98.22 %

$$X = \frac{H_c \quad .48(t_g - t_c) - h_b}{R_b}$$

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DATA AND RESULTS OF 24-HOUR BOILER TEST - Continued.

	WATER.	
57.	Total weight of water fed into boiler	329,983 lbs.
58.	Equivalent water fed into boiler from and at 212°F	383,526 lbs.
59.	Water actually evaporated corrected for quality of steam	324,109 lbs.
60.	Factor of evaporation	1.16226
61.	Equivalent water evaporated into dry steam and at 212°F (Item 59 x 60)	376,699 lbs.
	WATER PER HOUR	
62.	Water evaporated per hour corrected for quality of steam per hr.	13,504.54 lbs.
63.	Equivalent evaporation from and at 212°F per hour	15,693 lbs.
64.	Equivalent evaporation per hr. from and at 212°F per sq. ft. of water heating surface	3.12 lbs.
	HORSE POWER.	
65.	Horse power developed (34-1/2 lbs of water evaporated into dry steam from and at 212°F = 1 H. P.	454.92 H. P.
66.	Builders rated horse power	500 H. P.

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DATA AND RESULTS OF 24-HOUR BOILER TEST - Continued.

HORSE POWER - Continued.

67.	Percentage of Builders rated horse power developed...	90.95 %

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per lb. of coal as fired (Item 57 ÷ Item 25)...........	8.29 lbs.
69.	Equivalent evaporation from and 212°F per pound of coal as fired (Item 61 ÷ Item 25)..................	9.45 lbs.
70.	Equivalent evaporation from and at 212° F per lb. of dry coal (Item 61 ÷ Item 27).......................	9.6 lbs.
71.	Equivalent evaporation from and at 212° F per pound of combustible (Item 61 ÷ Item 30).................	10.44 lbs.

EFFICIENCY.

72.	Efficiency of the boiler; heat absorbed by the boiler per pound of combustible divided by the heat value of one lb. of combustible............................	70.6 %
73.	Efficiency of boiler, including grate; heat absorbed per lb. dry coal divided by heating value of 1 lb. of	69.2 %

COST OF EVAPORATION.

74.	Cost of	
75, 76.	Omitted. Cost of coal unknown	

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DATA AND RESULTS OF 24-HOUR BOILER TEST - Continued.

	Smoke Observation.	
77, 78, 79 Omitted.		
	Methods of firing already discussed.	
80, 81, 82, 83 are, therefore, omitted.		
	ANALYSIS OF DRY FLUE GAS.	
84.	Carbon Dioxide CO_2	5.28 %
85.	Oxygen O_2	12.30 %
86.	Carbon Monoxide	0.396
87) 88)	Nitrogen and Hydro Carbons burned	82.024
		100 %

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HEAT BALANCE FOR 24-HOUR TEST.

Heat Balance, or Distribution of the Heating Value of the Combustible for the 24-hour Boiler Test.

Total Heat Value of 1 lb. of combustible = 14331 B. T. U.

		B. T. U.	%
1.	Heat absorbed by boiler = Evaporation from and at 212° F per lb. of combustible x 965.7	10081.908	70.6 %
2.	Loss due to moisture in coal = % of moisture referred to combustible ÷ 100 x [(212−59) + 966 + 0.48 (443.5−212)]	26.75	0.186%
3.	Loss due to moisture formed by burning of hydrogen = % of hydrogen to combustible ÷ 100 x 9 x [(212 −) + 966 + 0.48 (− 212)]	Not Determined	
4.	Loss due to heat carried away in the dry chimney gases = wt. of gas per lb. of combustible x 0.24 x (443 − 59)	3,940	27.2%
5.	Loss due to incomplete combustion of carbon = $\frac{CO}{CO_2 + CO} \times \frac{\%C \text{ in combustible}}{100} \times 10{,}150$	44.2	0.308%
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for	158.142	1.706%
Totals		14331	100

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24-HOUR TEST.
DATA TAKEN AT TURBINE.

Time A.M.	Reading of Stroke Counter on Oil Pump	Average Strokes per Minute	Speed of Turbine R.P.M.	Vacuum on Turbine Exhaust "of H_g	Gauge Pressure at Turbine #/in ^{2}	Oil Cooling Water Meter Reading
1:00				26.05	145	17344
15	20748			26	140	17354
30	23466	181.2	3805	26	145	17371
45	26189	181.5	3810	26	147	17385.5
2:00	28920	182	3820	26	147	17401
15	31654	182.26	3830	26	145	17416
30	34402	183.2	3850	25.9	147	17434
45	37184	185.4	3900	25.77	148	17448
3:00	39960	185.0	3885	25.75	150	17465
15	42666	180.4	3790	25.78	150	17479
30	45412	183	3440	25.78	148	17494
45	48155	182.8	3939	25.8	150	17510
4:00	50900	183.0	3845	25.8	151	17526
15	53635	182.3	3825	25.8	149	17541
30	56392	183.6	3960	25.8	147	17555
45	59131	182.6	3835	25.8	150	17570
5:00	61873	182.8	3939	25.8	150	17580
15	64620	183.1	3850	25.8	150	17601
30	67365	183	3840	25.8	150	17616
45	70120	192.3	4040	25.8	150	17631
6:00		183.3	3445			
15	75623	183.3	3850	25.9	145	17662
30	78354	182.06	3820	25.9	143	17678
45	81097	182.8	3939	25.9	145	17694
7:00	83826	181.9	3819	25.9	145	17710

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24-HOUR TEST.
DATA TAKEN AT TURBINE.

Time A.M.	Reading of Stroke Counter on Oil Pump	Average Strokes per Minute	Speed of Turbine R.P.M.	Vacuum on Turbine Exhaust "of H_g	Gauge Pressure at Turbine #/in^2	Oil Cooling Water Meter Reading
7:15	86684	186	3905	25.9	143	17725
30	89282	177.2	3720	26.	145	17740
45	91977	186.3	3960	25.9	140	17755
8:00	94693	181.06	3804	26	140	17772
15	97395	180	3780	25.7	140	17787
30	00104	211.2	4440	25.7	130	17802
45	02777	178	3760	25.4	140	17821
9:00	05470	179.5	3770	25.2	140	17840
15	08186	181.07	3905	25.4	145	17857
30	10801	174.1	3658	25.4	145	17875
45	13585	185.6	3900	25.4	145	17896
10:00	16315	182	3820	25.4	145	17911
15	18990	178.5	3750	25.3	150	17930
30	21680	179.1	3760	25.4	140	17948
45	24407	180	3780	25.3	144	17968
11:00	27100	179.5	3770	25.3	139	17986
15	29790	179.2	3765	25.3	150	18004
30	32495	180.3	3790	25.4	140	18022
45	35230	183.6	3955	25.3	144	18042
12:00	31905	178	3740	25.3	145	18059
15	40600	179.6	3770	24.9	145	18079
30	43286	179.1	3760	24.	143	18096
45	45969	179.	3759	25.1	143	18117
1:00	48683	181.2	3804	25.3	142	18133

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24-HOUR TEST.
DATA TAKEN AT TURBINE.

Time P.M.	Reading of Stroke Counter on Oil Pump	Average Strokes per Minute -	Speed of Turbine R.P.M.	Vacuum on Turbine Exhaust " of H_g	Gauge Pressure at Turbine #/in ^{2}	Oil Cooling Water Meter Reading
1:15	51380	179.8	2775	25.3	142	18157
30	54080	180.0	3780	25.3	141	18177
45	57865	185.8	3900	25.3	145	18192
2:00	59656	185.6	3885	25.8	146	18212
15	62212	170.4	3580	25.8	144	18225
30	64870	177	3719	25.8	148	18241
45	67615	183	3840	25.8	138	18259
3:00	70293	178.5	3750	25.85	141	18275
15	72998	180.3	3790	25.8	142	18291
30	75700	180	3780	25.9	142	18308
45	78400	180	3780	25.8	142	18325
4:00	81005	180.3	3790	25.9	137	18343
15	83775	178	3750	25.8	138	18358
30	86460	179	3759	25.8	139	18375
45	89167	180	3780	25.8	141	18393
5:00	91870	180.2	3785	25.8	141	18412
15	94575	180.2	3785	25.8	143	18427
30	97268	179.2	3765	25.8	140	18444
45	99937	177.9	3735	25.	142	18461
6:00	102649	180.8	3800	25.9	143	18479
15	105338	179.9	3778	26.	145	18491
30	108023	179.	3759	25.7	140	18505
45	110645	175	3678	25.8	145	18514
7:00	113315	184.6	3875	25.9	140	18534

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24-HOUR TEST.
DATA TAKEN AT TURBINE.

Time P.M.	Reading of Stroke Counter on Oil Pump	Average Strokes per Minute	Speed of Turbine R.P.M.	Vacuum on Turbine Exhaust "of H_g	Gauge Pressure at Turbine $\#/in^2$	Oil Cooling Water Meter Reading
7:15	115964	176.7	3710	25.95	141	18547
30	118628	177.8	3730	25.95	142.5	18561
45	121012			25.82	142	18575
8:00	123672	177.2	3720	25.9	144	18589
15	126336	177.8	3730	26.1	142	18602
30	128998	177.8	3730	24.7	145	18616
45	130776			26.5	146	18629
9:00	133436	177.2	3720	25.7	146	18643
15	136100	177.8	3730	25.6	142	18657
30	138752	177.	3719	25.8	141	18671
45				25.8	142	18686
10:00	142218			25.8	140	18699
15	144883	173.5	3640	25.8	145	18712
30	147566	185.5	3895	25.8	148	18729
45	150228	177.8	3735	25.8	142	18741
11:00	152909	178.5	3750	25.8	146	18755
15	155591	178.6	3755	25.8	144	18769
30	158262	178.0	3740	25.9	147	18782
45	160937	178.2	3745	25.7	Pressure	18795
12:00	163618	178.5	3750	25.8	Gauge	18808
15	166347	181.5	3810	25.8	gave	18821
30	169055	180.5			out.	18835
45	171798	182.5	3830	25.8		18849
1:00	174541	182.5	3830	25.8		18862
AV.		180.7	3795	25.6	144.4	

Total Amount of Oil Cooling Water Used = 1518 cu. ft.

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DATA TAKEN AT TURBINE.

AM.	POWER FOR MOTOR PUMP FOR CIRCULATING CONDENSER WATER			CONDENSING WATER		
Time	Volts.	Amps.	K-Watts	Inlet Temp. F°	Outlet Temp. F°	Range of Temp. F°
1:00				43	86	43
1:15				46	88	42
1:30	545	15.94	8.69	41	88	47
1:45	537	15.94	8.56	42	82	40
2:00	548	15.94	8.75	42	85	43
2:15	540	15.94	8.62	42.5	84	41.5
2:30	545	13.84	7.55	43.	80	37
2:45	545	14.24	7.76	41	86	45
3:00	543	14.34	7.65	43	90	47
3:15	543	14.24	7.75	42	90	48
3:30	540	14.24	7.68	44	86	42
3:45	542	14.24	7.72	43	86	43
4:00	540	14.24	7.68	42	87	45
4:15	542	14.34	7.77	42	90	48
4:30	540	14.34	7.75	43	86	43
4:45	540	14.44	7.8	43	86	43
5:00	541	13.94	7.55	42	87	45
5:15	543	14.34	7.8	43	80	37
5:30	550	14.24	7.84	44	90	46
5:45	541	14.	7.57	44	80	36
6:00						
6:15	547	14.9	8.15	44	71	27
6:30	547	16.2	8.86	45	74	29
6:45	550	15.5	8.54	45	78	33

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DATA TAKEN AT TURBINE.

AM	POWER FOR MOTOR PUMP FOR CIRCULATING CONDENSER WATER			CONDENSING WATER		
Time	Volts.	Amps.	K-Watts	Inlet Temp. F°	Outlet Temp. F°	Range of Temp. F°
7:00	530	15.7	8.32	44	88	44
15	540	16.9	9.12	44	82	38
30	530	16.7	8.85	44	85	41
45	535	16.9	9.04	44	88	44
8:00	535	16.3	8.72	45	88	43
15	545	16.7	9.1	46	90	44
30	553	16.5	9.14	46	95	49
45	540	17.3	9.35	46.5	90	43.5
9:00	540	17.2	9.28	47.5	88	40.5
15	530	17.3	9.18	48	88	40
30	553	17.3	9.58	48	89	41
45	545	17.5	9.54	48	90	42
10:00	540	17.7	9.56	49	88	39
15	535	17.7	9.47	49	89	40
30	541	18.1	9.8	50	88	38
45	545	18.4	10.01	51	92	41
11:00	550	18.2	10	52	89	37
15	550	18.4	10.1	53	93	40
30	540	17.9	9.68	53	90	37
45	555	18.2	10.1	54	93	39
12:00	545	18.	9.81	55	92	37
15	535	18.1	9.69	56	98	42
30	530	18.4	9.75	50	86	36
45	540	19.7	10.6	48	84	36

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DATA TAKEN AT TURBINE.

	POWER FOR MOTOR PUMP FOR CIRCULATING CONDENSER WATER			CONDENSING WATER		
PM Time	Volts	Amps.	K-Watts	Inlet Temp. F°	Outlet Temp. F°	Range of Temp. F°
1:00	545	19.9	10.62	47	76	29
15	535	19.5	10.4	48	81	33
30	545	19.1	10.4	48	86	38
45	540	18.9	10.2	49	92	43
2:00	545	19.	10.35	50	85	35
15	550	19.1	10.5	50	85	35
30	545	19.3	10.5	51	87	36
45	545	19	10.35	52	86	34
3:00	848	19	10.42	52	85	33
15	540	18.8	10.15	53	86	33
30	550	18.9	10.4	54	89	35
45	530	18.9	10	55	90	35
4:00	535	18.5	9.9	51	86	35
15	540	18.7	10.1	50	83	33
30	552	19.9	10.95	50	85	35
45	546	18.7	10.21	51.5	86	34.5
5:00	532	18.3	9.75	52.	85	33.0
15	525	18.3	9.6	53.	86	33
30	521	19.6	10.2	54.	89	35
45	525	19.1	10.	54.	92	38
6:00	510	19.4	9.9	55	88	33
15	555	19.1	10.6	55	99	34
30	545	19.3	10.5	55	92	37
45	556	19.2	10.65	56	96	40

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DATA TAKEN AT TURBINE.

	POWER FOR MOTOR PUMP FOR CIRCULATING CONDENSER WATER			CONDENSING WATER		
PM Time	Volts	Amps.	K-Watts	Inlet Temp. F°	Outlet Temp. F°	Range of Temp. F°
7:00	527	19.3	10.2	56	94	38
15	540	19.1	10.3	57	94.2	37.2
30	535	19.	10.2	57	96	39
45	535	19	10.2	57.5	98	40.5
8:00	535	19.1	10.2	58	99	41.0
15	538	19.1	10.26	54	94	40
30	535	20.2	10.8	51	90	39
45	555	20.1	11.15	51	87	36
9:00	557	19.8	11.	51.5	88	36.5
15	547	19.6	10.7	52.5	90	37.5
30	549	19.5	10.7	53.5	90	36.5
45	555	19.5	10.8	55.	92	37
10:00	555	19.4	10.78	55.5	92	36.5
15	552	19.3	10.62	56.5	94	37.5
30	542	19.2	10.4	57.	93	36.0
45	540	19.2	10.36	58	95	37.0
11:00	546	19.1	10.4	58.5	96	37.5
15	542	19.	10.3	60	99	39.0
30	542	18.8	10.2	61	98	37.0
45	538	18.8	10.1	64	102	38
12:00	547	18.7	10.2	65	100	35
15	559	18.8	10.5	60	93	33
30	560	19.6	11	54	82	28
45	560	20.2	11.3	51	72	21
			9.625	50.08	88.4	38.32

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The Measurement of the Power Output of the 400 K. W. Turbo-Alternator.

The power output of the Turbo-Alternator was measured by the two wattmeter method using the instruments in the secondaries of Potential and Current transformers.

The transformers and instruments used were all calibrated. The instruments were connected as shown in the diagram of Connection for measuring the power output of the 400 K. W. 3-phase Alternator. The numbers of the instruments are given on this diagram.

List of Instruments Used.

G & E Potential Transformer No. 302721 and
Westinghouse Series Transformer No. 49203
used with the following instruments:-
- Weston A. C. Voltmeter No. 5102,(0 to 150)
- Weston Wattmeter No. 2859, (0 to 150)
- Weston A. C. Ammeter No. 291, (0 to 5)

G & E Potential Transformer No. 302723 and
Westinghouse Series Transformer No. 49182
were used with the following instruments:-
- Weston A. C. Voltmeter No. 3408,(0 to 150)
- Weston Wattmeter No. 267, (0 to 1500)
- Westinghouse Ammeter No. 104502,(0 to 5)

Other Electrical Instruments.

For measuring power consumed in exciting the Turbo-Alternator:-

- Weston D. C. Ammeter No. 16258,(0 to 75)
- Weston D. C. Voltmeter No. 16808,(0 to150)

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For Measuring power input into motor driving Condensing Water Circulating Pump:-

Weston D. C. Voltmeter No. 12027, (0 to 750)
Weston D. C. Ammeter No. 6010, (0 to 25amp.)

Note:- (To accompany Log of Electrical Data.)

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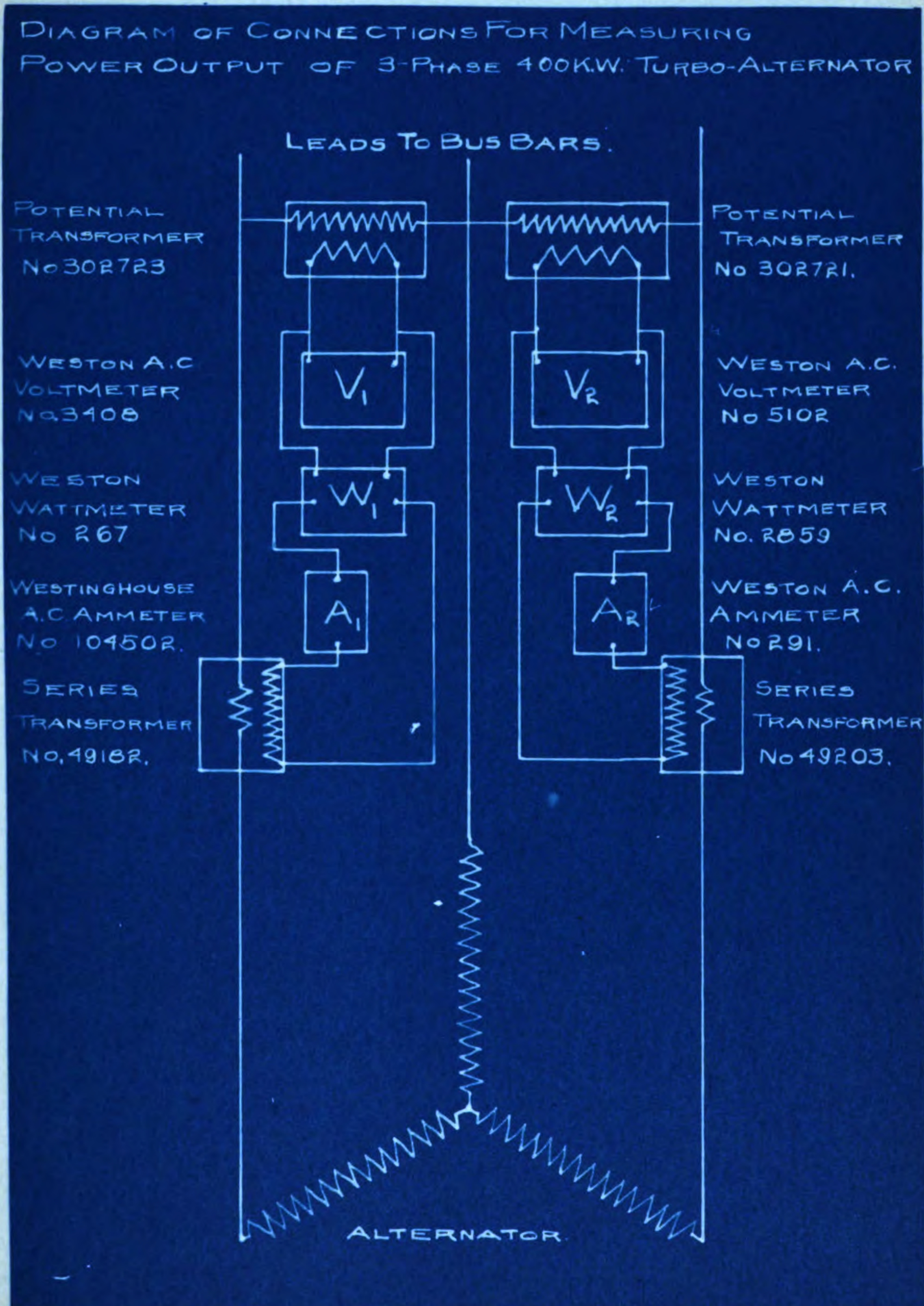

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CORRECTED ELECTRICAL READINGS FOR TURBO GENERATOR

AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
1:00	214	113.4	2.02	40.2	102.9	179	114.2	1.82
1: 2	210	113.4	2.02	40.2	102.9	177	114.1	1.79
1: 4	210	113.	2.03	40.2	102.9	180	113.9	1.82
1: 6	214	112.9	2.045			183	114.	1.84
1: 8	214	113.4	2.05			184	114.1	1.84
1:10	204	112.9	1.89			165	113.9	1.59
1:12	200	112.8	1.58			157	113.8	1.61
1:14	196	112.7	1.55	39.7	101.9	153	113.7	1.59
1:16	214	112.9	2.05			183	113.9	1.85
1:18	212	112.7	2.04			184	113.9	1.85
1:20	210	112.9	1.97			171	114.0	1.77
1:22	196	112.8	1.52			151	113.9	1.56
1:24	204	112.9	1.72			150	113.9	1.55
1:26	196	113.0	1.74			149	113.8	1.55
1:28	198	112.9	1.74	39.2	101.4	150	113.8	1.55
1:30	206	113.0	1.89			168	113.7	1.69
AV.	206	113.2	1.865	43.9	102.4	168	113.9	1.82

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-Continued.

AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
1:32	204	112.8	1.89			166	113.7	1.69
1:34	208	112.9	1.82			170	113.7	1.60
1:36	193	112.8	1.75			149	113.7	1.54
1:38	196	112.9	1.72			146	113.7	1.53
1:40	159	112.8	1.37			108	113.7	1.13
1:42	166	112.9	1.37			121	113.7	1.24
1:44	159	112.6	1.42	35	101.4	129	113.7	1.31
1:46	161	112.6	1.47			133	113.7	1.31
1:48	164	112.7	1.47			135	113.7	1.32
1:50	159	112.8	1.47			136	113.9	1.23
1:52	154	112.8	1.42			127	113.9	1.24
1:54	149	112.8	1.37			126	113.8	1.23
1:56	159	112.8	1.42			124	113.9	1.21
1:58	161	112.9	1.52			135	113.7	1.37
2:00	169	112.9	1.54	35.5	101.9	143	113.6	1.40
AV.	170.8	112.8	1.535		101.6	1365	113.7	1.35

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
2: 2	154	112.9	1.57			141	113.7	1.39
2: 4	151	112.9	1.45			121	113.7	1.20
2: 6	149	112.9	1.42			121	114.	1.18
2: 8	149	113.	1.37			121	114	1.17
2:10	159	112.9	1.47			135	113.7	1.31
2:12	154	112.8	1.44	34.5	100.9	128	113.7	1.22
2:14	140	112.9	1.33			108	114.	1.07
2:16	142	112.9	1.23			111	113.9	1.06
2:18	140	112.9	1.23			111	113.7	1.06
2:20	142	112.9	1.37			110	113.8	1.06
2:22	159	112.9	1.47			128	113.7	1.24
2:24	154	112.8	1.47			128	113.6	1.23
2:26	135	113.0	1.23			106	113.7	1.01
2:28	137	113.0	1.20	34.	100.4	106	114.	1.01
2:30	135	113.0	1.20			106	114.	1.01
AV.	147.2	112.9	1 36	34.25	100.6	118.8	113.6	1 15
2:32	132	112.9	1.19			104	114.	1.00
2:34	145	112.9	1.34	34.5	100.9	120	113.8	1.17
2:36	145	112.9	1.34			120	113.8	1.17
2:38	130	113.1	1.19			104	114.0	1.00
2:40	132	113.0	1.18			102	114.0	1.00
2:42	132	113.0	1.18			101	113.9	1.00
2:44	130	113.1	1.17	34	100.4	104	114.0	1.00
2:46	130	113.0	1.31			122	113.9	1.18
2:48	148	112.9	1.36			121	113.8	1.17
2:50	149	112.8	1.35			121	113.8	1.18
2:52	130	112.6	1.18			102	113.8	0.98
2:54	129	112.8	1.17			101	113.8	0.98
2:56	130	112.9	1.15			101	114.2	0.97
2:58	139	112.6	1.31	34.5	99.9	105	113.8	1.14
3:00	149	112.8	1.43			126	113.8	1.25
AV.	136.5	112.9	1 26	34.33	100.4	111	113.9	1 08

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
3: 2	135	112.9	1.23			111	113.9	1.06
3: 4	135	112.8	1.23	34.	99.9	111	113.9	1.06
3: 6	132	112.7	1.22			109	114.0	1.06
3: 8	135	112.9	1.23			110	113.9	1.06
3:10	149	112.7	1.40			126	113.9	1.22
3:12	150	112.8	1.41			126	113.8	1.23
3:14	129	113.0	1.18	34	99.9	103	114.1	1.00
3:18	130	112.8	1.17			103	114.1	1.00
3:20	145	112.6	1.34			121	113.7	1.17
3:22	140	112.8	1.24			111	113.8	1.07
3:24	138	112.7	1.24			111	113.7	1.07
3:26	123	112.9	1.10	34	99.9	95	114.0	.86
3:28	123	112.9	1.10			95	114.0	.86
3:30	121	112.9	1.09			95	114.0	.86
AV.	134.1	112.9	1 22	34	99.9	108.5	113.9	1.04
3:32	121	112.9	1.09			95	113.9	0.86
3:34	135	112.7	1.25	34	99.9	109	113.7	1.06
3:36	137	112.9	1.26			109	113.8	1.06
3:38	121	112.9	1.10			95	113.9	0.86
3:40	122	112.9	1.10			96	113.9	0.88
3:42	123	112.9	1.10			95	113.8	0.86
3:44	126	112.9	1.13			95	113.7	0.86
3:46	121	113.	1.10	34	99.9	94	113.7	0.86
3:48	123	112.9	1.10			95	113.7	0.86
3:50	124	112.9	1.11			95	113.7	0.86
3:52	123	113.	1.10			95	113.7	0.86
3:54	123	112.9	1.10			94	113.6	0.86
3:56	123	112.9	1.10			95	113.6	0.86
3:58	123	112.9	1.10			94	113.6	0.86
4:00	122	113.	1.10			95	113.7	0.87
AV.	124.5	112.9	1112	34	99.9	96.1	113.7	.89

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
4:02	126	113	1.11			95	113.7	0.86
4: 4	121	112.9	1.09	34	99.4	95	113.7	0.86
4: 6	123	113	1.10			95	113.7	0.86
4: 8	126	113	1.11			95	113.7	0.88
4:10	130	112.9	1.18			101	113.6	0.99
4:12	131	112.8	1.18			101	113.6	0.99
4:14	131	112.8	1.18	34.5	99.9	102	113.4	1.00
4:16	132	112.9	1.19			102	113.3	1.00
4:18	133	112.8	1.20			102	113.4	1.00
4:20	130	112.7	1.18			102	113.7	1.00
4:22	131	112.8	1.18			102	113.6	1.00
4:24	130	112.7	1.18			101	113.4	1.00
4:26	132	112.6	1.19			101	113.4	1.00
4:28	133	112.6	1.20			102	113.5	1.00
4:30	133	112.8	1.20			102	113.5	1.00
AV.	129.5	112.8	1 16	34.25	99.65	99.9	113.5	.96
4:32	129	113.0	1.13			95	113.7	0.88
4:34	126	112.7	1.10			95	113.6	0.88
4:36	126	112.9	1.13	34	99.9	98	113.6	0.96
4:38	126	113.0	1.11			95	113.7	0.91
4:40	125	112.9	1.11			96	113.5	0.95
4:42	126	113.0	1.11			95	113.4	0.94
4:44	126	113.	1.12			99	113.4	0.96
4:46	126	113.	1.13	34	99.4	96	113.4	0.96
4:48	126	112.9	1.12			97	113.4	0.96
4:50	126	112.9	1.12			96	113.7	0.93
4:52	130	112.7	1.14			99	113.4	1.06
4:54	128	112.7	1.12			99	113.4	1.06
4:56	128	112.4	1.11			98	113.3	0.96
4:58	128	112.4	1.11			99	113.2	1.06
5:00	126	112.4	1.13	34	99.4	99	113.3	1.06
AV.	125.1	112.8	1 12	34	99.4	96.4	113.5	.97

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
5: 2	126	112.6	1.17	34	99.4	99	113.3	1.06
5: 4	128	112.6	1.17			99	113.3	1.16
5: 6	126	112.9	1.13			98	113.4	1.06
5: 8	111	113.7	1.02			92	113.4	0.91
5:10	112	113.9	1.03			94	113.6	0.93
5:12	111	113.9	1.03			95	113.5	0.94
5:14	116	113.8	1.05	33	98.4	95	113.6	0.94
5:16	111	113.9	1.03			95	113.6	0.94
5:18	110	113.9	1.02			95	113.5	0.94
5:20	109	113.9	1.02			92	113.3	0.94
5:22	118	113.8	1.10			101	113.5	0.99
5:24	126	113.6	1.23			118	113.3	1.20
5:26	135	113.4	1.28			123	113.4	1.19
5:28	130	113.6	1.28	34	98.9	121	113.4	1.19
5:30	116	113.8	1.13			101	113.7	1.01
AV.	119	113.5	1 16	33.66	99.15	101.1	113.5	1.03
5:32	121	113.7	1.10			102	113.7	1.01
5:34	118	114.	1.10	34	98.9	103	113.8	1.02
5:36	117	113.7	1.10			102	113.7	1.01
5:38	116	113.8	1.10			101	113.7	1.00
5:40	145	112.4	1.17			114	113.5	1.10
5:42	140	112.4	1.27			109	113.7	1.06
5:44	135	112.6	1.18			99	113.7	0.97
5:46	133	112.6	1.19	34	98.9	99	113.7	0.97
5:48	135	112.4	1.19			99	113.7	0.97
5:50	130	112.2	1.16			99	113.7	0.97
5:52	131	112.6	1.15			99	113.7	0.97
5:54	132	112.6	1.18			98	113.7	0.97
5:56	130	112.4	1.15			99	113.7	0.91
5:58	129	112.6	1.15			101	113.6	0.91
6:00	130	112.6	1.16	34	98.9	99	113.5	0.96
AV.	129.5	112.8	115.8	34	98.9	101.5	113.6	.99

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AM TIME	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
6: 2	126	112.5	1.13	34	98.9	99	113.5	0.96
6: 4	128	112.6	1.13			99	113.7	0.96
6: 6	135	113.4	.98			96	114.0	0.91
6: 8	106	113.6	.93			88	113.4	0.76
6:10	87	113.7	.83			83	113.3	0.71
6:12	92	113.6	.78			78	113.7	0.66
6:14	93	113.6	.81			81	113.1	0.67
6:16	87	113.4	.74	32.5	96.9	79	113.2	0.67
6:18	92	113.4	.83			82	113.1	0.67
6:20	89	113.4	.78			74	113.0	0.67
6:22	92	113.4	.80			78	113.2	0.67
6:24	97	113.2	.95			82	113.3	0.67
6:26	102	113.2	1.00			92	113.2	0.76
6:28	109	113.2	.94	35	96.9	82	113.2	0.76
6:30	108	113.4	.98			82	113.3	0.76
AV.	103	113.2	.91	33.83	97.6	85	113.5	.75
6:32	116	113.4	1.03			101	113.5	1.00
6:34	116	113.4	1.03	35	96.9	92	113.5	0.96
6:36	114	113.4	1.01			92	113.5	0.96
6:38	116	113.4	1.03			92	113.6	0.96
6:40	114	113.4	1.01			92	113.5	0.96
6:42	116	113.6	1.02			94	113.5	0.96
6:44	118	113.4	1.01			92	113.5	0.91
6:46	118	113.6	1.05	35	96.4	98	113.6	0.99
6:48	114	113.5	1.02			92	113.7	0.96
6:50	192	113.4	1.92			193	113.7	1.82
6:52	164	113.4	1.62			130	113.4	1.41
6:54	183	113.4	1.68			140	113.7	1.67
6:56	183	113.4	1.68			169	113.7	1.62
6:58	192	113.4	1.97	37.7	93.9	155	113.7	1.87
7:00	187	113.2	1.82			159	113.7	1.77
AV.	142.5	113.5	1.32	35.9	95.7	119.5	113.6	1.26

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
7: 2	208	113.1	2.13	39.7	96.9	197	113.7	2.02
7: 4	178	113.6	1.62	37.7	92.9	163	113.7	1.62
7: 6	187	113.2	1.74	37.7	93.9	189	113.6	1.69
7: 8	208	113.1	1.92			197	113.2	2.07
7:10	200	113.6	1.87			207	114.2	2.02
7:12	173	113.2	1.72	37.7	93.4	150	113.7	1.47
7:14	144	113.2	1.28			123	113.7	1.22
7:16	178	113.2	1.87			169	113.7	1.70
7:18	149	113.2	1.47			130	113.4	1.31
7:20	178	113.2	1.62			159	113.7	1.63
7:22	154	113.4	1.46			130	113.7	1.47
7:24	107	112.6	1.28			92	113.5	1.31
7:26	135	112.6	1.67			121	113.7	1.41
7:28	200	112.6	1.87	38.2	96.4	169	114.3	1.97
7:30	192	112.6	1.67			179	113.7	2.07
AV.	172.9	113.	1.68	38.2	94.9	158	113.6	1.67
7:32	208	112.6	1.67			140	113.5	1.53
7:34	200	112.6	1.87			188	113.9	1.92
7:36	173	113.4	1.77			169	113.7	1.67
7:38	200	113.4	1.97			188	113.7	1.87
7:40	173	113.4	1.72	39.7	97.9	169	113.6	1.72
7:42	249	113.4	2.51			130	113.8	1.62
7:44	200	113.4	2.02			197	113.8	2.02
7:46	229	113.4	2.09			220	113.7	2.29
7:48	215	113.6	2.09			227	113.8	2.26
7:50	182	112.9	1.57			150	113.9	1.67
7:52	200	113.6	1.92			188	114.0	1.92
7:54	215	113.9	1.97	39.3	93.9	197	113.9	1.92
7:56	173	113.4	1.62			150	114.1	1.62
7:58	208	113.2	1.97			197	114.0	1.97
8:00	192	113.8	1.97			179	113.9	1.82
AV.	201	113.4	1.78	39.5	95.9	179.2	113.9	1.98

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
8: 2	182	113.4	1.72	40.7	93.9	140	113.8	1.52
8: 4	236	113.2	2.02			197	114.1	2.02
8: 6	215	112.9	2.07			205	113.9	2.11
8: 8	200	112.9	2.07			188	113.8	1.92
8:10	200	112.9	1.92			197	114.1	1.87
8:12	229	113.2	2.36	40.1	94.9	220	114.1	2.35
8:14	215	113.4	2.46			227	114.4	2.30
8:16	229	113.4	1.97			212	114.2	2.11
8:18	200	113.4	1.97			188	113.7	1.92
8:20	173	113.4	1.62			159	113.8	1.60
8:22	236	113.2	2.02	39.7	93.9	205	113.8	2.11
8:24	182	113.4	2.71			179	113.8	1.72
8:26	296	113.	1.77			150	113.9	1.72
8:28	218	113.4	1.97			197	114.1	2.07
8:30	225	113.0	2.36	42.5	97.9	227	113.8	2.40
AV.	215.8	113.2	2.07	40.7	97.6	192.8	114.	1.98
8:32	211	113.4	1.97			212	114.2	2.11
8:34	200	113.2	1.97			188	114.2	1.92
8:36	211	113.4	2.07			197	113.9	2.00
8:38	168	113.2	1.62	38.7	92.9	140	113.8	1.55
8:40	203	113.3	1.92			179	113.8	1.87
8:42	233	113.2	2.44			227	113.9	2.40
8:44	211	113.4	2.21			197	113.7	2.07
8:46	192	113.4	1.57			179	113.8	1.85
8:48	173	113.4	1.57	39.7	92.9	140	113.7	1.55
8:50	229	113.2	1.92			179	113.9	1.82
8:52	215	113.4	1.97			205	113.9	2.16
8:54	215	113.6	2.00			197	113.8	2.16
8:56	222	113.4	2.36			220	113.8	2.21
8:58	173	113.4	2.55	39.2	91.9	150	113.9	1.62
9:00	182	113.2	2.36			242	113.8	1.62
AV.	202.2	113.3	2.04	39.2	92.9	190	113.9	1.93

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
9: 2	192	113.2	1.62	41.6	96.9	179	113.9	1.82
9: 4	218	113.3	2. 21			212	113.7	2.18
9: 6	218	113.4	2.31			220	113.9	2.26
9: 8	211	113.4	2.16			212	113.9	2.11
9:10	196	113.4	1.92			188	113.8	1.87
9:12	200	113.4	1.82	40.2	94.9	188	113.9	1.92
9:14	188	113.2	1.62			159	114.1	1.62
9:16	215	113.4	1.77			197	113.8	2.07
9:18	204	113.5	1.97			197	114.0	2.02
9:20	222	113.4	2.21			220	113.9	2.33
9:22	211	112.9	1.92	40.2	94.9	197	113.8	1.99
9:24	203	113.2	1.92			188	114.0	1.97
9:26	182	113.4	1.52			159	114.	1.65
9:28	200	113.2	1.67	42.5	97.9	169	113.8	1.72
9:30	200	113.6	1.92			197	113.7	1.95
AV.	204	113.3	1.90	41.12	96.1	192.2	113.8	1.96
9:32	192	113.4	1.92			188	114.	1.92
9:34	111	113.4	2.16	40.2	94.9	205	113.9	2.12
9:36	196	113.4	1.97			188	113.8	1.92
9:38	173	113.2	1.57			150	113.9	1.72
9:40	200	113.2	1.97			188	113.8	1.92
9:42	200	113.4	2.16			188	113.9	1.97
9:44	236	113	2.41			227	113.9	2.40
9:46	203	113.4	2.02	42.1	95.9	188	113.8	1.92
9:48	188	113.4	1.77			159	114.3	1.62
9:50	107	113.4	2.02			188	113.9	1.92
9:52	211	113.4	1.97	40.2	95.9	197	113.8	2.02
9:54	215	113.2	2.16			205	114.2	2.11
9:56	225	113.3	2.26			212	114.0	2.21
9:58	196	113.4	2.07			179	114.1	1.81
10:00	200	113.3	1.87			188	113.9	1.90
AV.	190	113.3	2.02	40.83	95.5	190	113.9	1.96

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
10: 2	211	113.2	2.07	40.2	94.9	205	113.9	2.09
10: 4	215	113.2	2.16			197	114.1	2.02
10: 6	226	112.9	2.16			220	114.	2.30
10: 8	229	113.4	2.21			235	114.1	2.41
10:10	215	113.2	2.08			205	113.6	2.09
10:12	211	113.4	2.16	43.5	98.9	212	113.9	2.12
10:14	208	113.4	1.77			188	114.0	1.91
10:16	211	113.4	2.12			197	113.9	2.07
10:18	240	113.2	2.65			235	113.2	2.49
10:20	236	113.2	2.41			242	113.5	2.50
10:22	229	113.4	1.97			197	113.7	1.99
10:24	154	113	1.52	43.	98.9	159	113.8	1.67
10;26	203	113.4	2.07			197	114.1	2.03
10:28	192	113.4	1.77			169	114.0	1.75
10:30	211	113.2	2.21			205	114.0	2.07
AV.	212.8	113.3	2.08	42.2	97.6	204.5	113.8	2.10
10:32	229	113.4	2.21	42.5	97.9	227	114.	2.30
10;34	218	113.4	2.02			205	114.2	2.02
10:36	221	113.6	2.16			212	113.9	2.20
10:38	211	113.2	1.97			205	113.9	2.10
10:40	221	113.0	2.07	42.5	97.4	212	114.	2.11
10:42	243	113.2	2.45			242	114.1	2.65
10:44	207	113.4	2.45			242	113.8	2.60
10:46	229	113.4	2.07			188	113.9	1.87
10:48	200	113.2	2.36			227	114.1	2.40
10:50	236	113.4	1.77	43.	93.9	188	114.2	1.87
10:52	221	113.5	2.26			227	114.	2.40
10:54	211	113.6	2.21			227	114.2	2.30
10:56	201	113.4	1.92			205	114.1	2.05
10:58	243	113.4	1.97			179	114.	1.87
11:00	207	113.2	1.92			188	113.6	1.92
AV.	220	113.4	2.12	42.7	96.4	211.6	113.9	2.18

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AM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
11: 2	200	113.4	1.72	40.2	94.4	179	113.7	1.77
11: 4	251	113.1	2.55			250	113.8	2.65
11: 6	225	112.9	2.16			212	113.6	2.16
11: 8	221	113.0	2.21			212	113.9	2.18
11:10	218	113.2	2.16			212	114.2	2.17
11:12	229	113.2	2.16	41.6	95.9	227	113.8	2.34
11:14	207	113.1	2.16			212	113.7	2.20
11:16	229	113.2	2.26			235	113.9	2.45
11:18	218	113.0	2.21			220	113.9	2.22
11:20	192	113.2	1.97			179	113.8	1.85
11:22	211	113.3	2.02	41.1	95.9	188	113.7	1.89
11:24	178	113.0	1.57			169	113.9	1.69
11:26	211	113.2	1.92			205	114.1	2.02
11:28	211	113.2	1.97			205	113.7	2.07
11:30	221	113.4	1.97			205	113.8	2.07
AV.	214.8	113.1	2.07	40.98	95.4	207.5	113.9	2.12
11:32	200	113.2	1.92	39.2	92.9	188	113.8	1.97
11:34	187	113.4	1.67			179	113.8	1.72
11:36	203	113.	1.72			188	113.7	1.87
11:38	211	113.2	2.12			205	113.9	2.11
11:40	221	113.0	2.07	41.1	94.9	205	113.9	2.11
11:42	200	113.4	1.77			188	113.9	1.92
11:44	203	112.9	1.92			205	113.7	2.02
11:46	218	113.2	2.13			220	113.9	2.18
11:48	200	112.8	1.82	40.6	94.4	188	114.2	1.87
11:50	218	113.2	2.07			220	114.2	2.22
11:52	229	113.4	2.45			205	114.1	2.14
11:54	229	112.9	2.21			227	113.7	2.35
11:56	211	113.2	1.92			205	113.9	2.07
11:58	192	113.4	1.72	38.7	92.4	188	113.8	1.87
12:00	221	113.4	2.36			220	114.2	2.25
AV.	209.9	113.1	1.98	39.9	93.6	202	113.9	2.10

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
12: 2	192	113.2	1.77	39.2	93.9	188	114	1.87
12: 4	215	113.	1.97			197	113.8	1.97
12: 6	221	113.4	2.16			227	114.1	2.33
12: 8	203	113.2	1.82	39.9	94.9	205	114.	2.07
12:10	203	113.4	1.97			188	113.9	1.87
12:12	215	112.8	1.72			205	113.9	2.07
12:14	236	111.9	2.45			227	113.7	2.28
12:16	236	111.7	2.50	44.4	99.9	227	113.9	2.30
12:18	225	112.0	2.12	42.5	97.9	212	114.2	2.30
12:20	218	111.9	2.11	41.6	95.9	190	113.9	1.92
12:22	211	112.0	1.90	41.6	95.9	179	113.9	1.31
12:24	229	112.0	2.21	41.6	96.9	207	113.7	2.26
12:26	209	111.9	2.12	41.1	94.9	188	114.	1.87
12:28	221	111.9	2.07	41.6	94.9	199	113.9	1.82
12:30	232	112.0	2.21	41.6	96.9	205	114.	2.02
AV.	218	112.4	2.07	41.5	96.2	203	113.9	2.02

PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
12:32	218	111.8	2.09			191	113.7	1.77
12:34	221	111.7	2.31	42.5	96.9	205	113.7	2.11
12:36	215	111.8	2.07			188	113.9	1.87
12:38	243	111.7	2.36	42.5	97.9	227	113.7	2.30
12:40	232	111.8	2.26			205	113.7	2.07
12:42	221	111.9	2.21	43.9	98.9	203	113.7	2.02
12:44	251	111.6	2.40			227	114.2	2.29
12:46	218	111.9	2.12	41.6	95.9	197	113.9	1.97
12:48	211	112.	2.02	42.5	95.9	183	113.9	1.82
12:50	203	111.7	1.97	40.7	94.9	188	113.9	1.87
12:52	211	111.6	1.99	39.7		203	113.7	1.97
12:54	207	111.9	2.07	38.7	92.9	188	113.7	2.16
12:56	192	113.0	1.84	39.2	92.9	171	113.9	1.77
12:58	196	113.0	1.72	39.2	92.9	169	113.4	1.72
1:00	200	112.9	1.87		92.9	174	113.7	1.87
AV.	215.9	112.	2.09	41.0	95.2	194.5	113.8	1.97

PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
1: 2	192	112.9	1.87	40.6	95.9	159	113.9	1.77
1: 4	207	113.0	1.97	40.2	93.9	188	113.5	1.95
1: 6	200	113.0	1.92	41.6	95.9	179	113.7	1.97
1: 8	215	112.7	2.21	39.7	92.9	205	113.7	2.07
1:10	200	112.7	1.87	39.7	93.9	188	113.7	1.92
1:12	211	112.9	2.02	40.6	94.9	201	113.7	2.16
1:14	200	113.0	1.87	40.6	94.9	193	114.2	1.87
1:16	215	112.4	2.07	41.6	96.9	216	114.2	2.21
1:18	215	112.6	2.12	40.2	94.9	224	113.9	2.16
1:20	221	112.6	2.16	40.2	94.9	202	114.1	2.24
1:22	203	112.4	1.92	40.2	93.9	164	113.8	1.62
1:24	196	112.4	1.92	40.2	94.9	197	113.9	1.64
1:26	183	112.7	1.72	41.6	92.9	169	113.8	1.97
1:28	215	112.4	2.16	39.2	96.9	207	119.2	2.26
1:30	215	112.9	2.45	44.4	98.9	212	113.9	2.50
AV.	206	112.6	2.02	40.6	95.	193.8	113.8	2.02
1:32	203	112.4	1.92	41.6	95.9	188	113.8	1.89
1:34	203	112.4	1.87			179	113.9	1.87
1:36	192	112.4	1.72	39.7	93.9	167	113.2	1.77
1:38	207	112.4	1.87	40.1	92.9	193	113.2	1.87
1:40	207	112.1	2.02	43.9	96.9	201	112.7	2.11
1:42	229	112.1	2.36	41.6	95.9	231	113.2	2.50
1:44	192	112.4	1.82	38.7	92.9	179	112.7	1.87
1:46	183	112.4	1.82	40.1	94.9	167	112.8	1.82
1:48	192	112.1	1.72	39.2	92.9	169	113.2	1.67
1:50	200	112.1	1.82	40.1	94.9	205	113.2	1.87
1:52	218	112.4	2.02	41.1	95.9	205	113.1	2.07
1:54	211	112.4	2.07	42.5	97.9	211	112.9	2.16
1:56	200	112.4	1.92	38.7	92.9	188	113.2	1.89
1:58	164	112.4	1.82	39.7	93.4	180	113.2	1.57
2:00	192	112.4	1.87	39.7	93.5	179	113.2	1.77
AV.	199.5	112.39	1.91	40.5	94.5	187	113.3	1.91

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
2: 2	207	112.4	1.97	39.7	94.4	197	113.7	2.02
2: 4	232	112.6	2.36	40.6	95.9	227	113.7	2.45
2: 6	221	112.9	2.55	40.6	95.4	231	113.7	2.26
2: 8	218	112.7	2.07	42.0	95.9	205	113.7	2.16
2:10	218	112.4	1.97	39.7	94.9	227	113.7	2.21
2:12	209	112.4	2.12	39.7	93.9	197	113.7	1.97
2:14	192	112.4	1.87	39.7	93.9	193	113.7	1.82
2:16	221	112.8	2.12	39.7	93.9	212	113.7	2.16
2:18	243	112.7	2.65	41.1	96.4	242	113.7	2.60
2:20	258	112.4	2.70	41.1	95.4	257	113.7	2.75
2:22	207	112.9	1.77	40.2	93.9	188	113.7	1.92
2:24	215	112.8	2.36	41.1	95.9	205	113.2	2.07
2:26	192	112.9	1.77	40.2	94.9	169	113.7	1.72
2:28	221	112.4	2.16	42.5	97.9	205	114.0	2.07
2:30	221	112.4	2.16	43.5	98.4	220	114.2	2.26
AV.	218.2	112.5	2.17	40.8	95.5	211.5	113.7	2.16
2:32	207	112.6	2.07	41.6	96.9	205	114.2	2.11
2:34	207	112.7	1.97	39.7	93.9	201	113.7	2.07
2:36	178	112.9	1.87	41.1	96.9	174	114.2	1.67
2:38	200	113.2	1.97	41.1	94.9	197	113.7	1.92
2:40	207	112.9	2.07	40.5	94.9	212	114.	2.16
2:42	215	113.0	2.12	41.6	97.5	218	114.	2.21
2:44	213	112.9	2.21	42.5	97.9	212	113.7	2.16
2:46	221	112.9	2.31	43.0	96.9	235	114.	2.30
2:48	229	112.9	2.12	42.5	96.9	212	114.	2.07
2:50	207	112.9	2.07	39.7	92.9	212	114.2	2.07
2:52	215	113.0	2.21	42.0	97.9	218	114.2	2.16
2:54	207	112.9	2.16	42.5	96.9	205	113.9	2.16
2:56	215	112.8	2.12	41.6	95.9	212	114.2	2.16
2:58	207	112.9	1.97	40.6	94.9	208	114.	2.08
3:00	207	112.9	2.07	39.6	94.4	188	113.7	1.87
AV.	208.8	112.9	2.09	41.2	95.9	2.7.4	114.	1.94

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
3: 2	207	112.9	2.21	41.6	96.9	197	113.7	2.02
3: 4	207	112.9	1.97	40.6	95.9	197	113.7	2.21
3: 6	232	112.9	2.35	44.4	99.2	235	114.1	2.50
3: 8	221	112.9	2.26	43.5	97.9	235	114.1	2.45
3:10	192	112.9	2.12	41.6	97.4	197	114.1	1.97
3:12	192	113.1	1.87	40.2	93.9	188	114.1	1.92
3:14	215	112.9	2.07	41.6	96.9	212	114.1	2.16
3:16	207	112.9	1.97			205	114.1	2.02
3:18	221	112.7	2.02			212	114.1	2.16
3:20	218	113.2	2.10			216	114.1	2.16
3:22	203	113.0	1.97	40.6	93.9	197	114.1	2.02
3:24	236	112.9	2.21			205	114.1	2.26
3:26	229	112.8	2.12			197	114.2	2.16
3:28	240	112.7	2.21			218	113.7	2.35
3:30	215	113.1	2.12	46.8	92.9	188	114.2	2.02
AV.	215.5	112.9	2.10	42.4	96.5	206.2	114.	2.16
3:32	215	112.9	1.97	42.0	89.9	188	113.7	2.07
3:34	215	112.9	1.97	42.	89.9	187	113.7	1.95
3:36	229	112.9	2.21	42.5	90.9	216	114.2	2.34
3:38	221	112.7	2.16	42.5	90.9	193	113.9	2.21
3:40	215	112.9	2.21	42.5	91.9	195	113.8	2.02
3:42	215	112.9	2.02	42.5	91.9	193	113.7	2.11
3:44	221	112.4	2.07	42.5	91.4	193	113.7	2.12
3:46	215	112.9	2.07	43.	92.9	197	113.7	2.13
3:48	236	111.9	2.21	43.	92.9	205	113.7	2.13
3:50	255	112.4	2.21	43.4	23.9	220	113.9	2.46
3:52	275	113.1	2.70	44.4	96.9	227	114.7	2.66
3:54	247	113.4	2.21	43.4	94.9	218	116.7	2.17
3:56	243	112.9	2.45	43.4	94.9	208	115.9	2.29
3:58	229	113.9	2.16	43.4	93.9	193	115.2	2.00
4:00	215	111.9	1.97	43.4	93.9	169	115.7	1.82
AV.	229.9	112.9	2.17	42.9	92.7	199.8	114.2	2.16

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PM Time	W_2	V_2	A_2	I_F	E_F	W_2	V_2	A_2
4: 2	236	112.4	2.45	43.9	94.9	201	113.8	2.23
4: 4	258	111.9	2.55	44.4	96.9	231	114.2	2.60
4: 6	251	111.9	2.45	43.9	94.9	229	114.	2.44
4: 8	221	113.9	1.97	43.4	94.9	197	115.5	2.08
4:10	218	116.9	1.77	43.4	94.9	188	117.5	1.95
4:12	236	116.9	2.26	43.9	95.9	201	118.1	2.36
4:14	215	113.9	1.97	43.4	93.9	179	114.2	2.02
4:16	229	114.9	2.16	43.9	95.9	206	115.2	2.21
4:18	236	112.9	2.21	43.9	94.9	216	113.7	2.25
4:20	221	113.9	2.16	43.0	92.9	196	115.7	2.15
4:22	215	114.4	1.97	42.5	92.9	171	115.5	1.91
4:24	221	113.9	2.07	42.5	91.9	200	114.9	2.15
4:26	211	111.9	1.87	42.5	92.9	177	113.	1.94
4:28	243	112.4	2.35	43.4	94.9	231	113.9	2.48
4:30	236	112.9	2.45	43.4	94.9	231	113.6	2.42
AV.	230	114.	2 18	43.4	94.5	203.9	114.9	2.21
4:32	207	116.9	1.72	43.4	94.9	167	117.5	1.80
4:34	229	116.9	2.07	43.4	94.9	201	117.9	2.13
4:36	221	112.4	2.16	42.5	92.9	193	113.5	2.18
4:38	215	113.4	1.97	42.5	92.9	169	115.5	2.00
4:40	229	112.4	2.21	43.4	94.9	219	113.1	2.37
4:42	221	112.4	2.16	43.4	93.9	201	113.2	2.20
4:44	221	114.4	2.12	43.4	94.9	184	114.9	2.08
4:46	221	116.4	2.07	43.4	94.9	189	116.5	2.03
4:48	221	112.9	2.07	43.0	92.9	218	113.7	2.24
4:50	229	114.4	2.21	43.0	93.9	193	114.7	2.19
4:52	258	113.4	2.45	43.0	94.9	234	114.9	2.59
4:54	229	114.4	2.21	43.0	93.9	205	114.7	2.25
4:56	200	116.4	1.77	43.0	92.9	140	117.2	1.74
4:58	133	112.9	1.57	35.8	98.9	188	113.7	1.75
5:00	173	113.4	1.97	39.2	106.9	203	113.9	1.92
AV.	215.8	114.5	2 11	43.7	95.2	133.8	115.9	2.10

PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
5: 2	207	112.9	2.21	39.2	108.9	196	113.9	2.19
5: 4	207	112.9	2.21	38.2	110.9	221	114.	2.25
5: 6	207	112.9	2.21	38.2	111.9	224	114.3	2.49
5: 8	173	113.4	1.72	35.8	107.9	188	114.	1.81
5:10	215	113.4	2.26	40.2	106.9	216	113.9	2.14
5:12	200	113.4	1.97	40.6	107.9	196	113.9	2.06
5:14	215	113.4	2.07	39.7	105.9	205	114.2	2.13
5:16	229	113.4	2.45	41.6	110.9	227	114.1	2.33
5:18	229	112.9	2.21	40.6	108.9	225	114.	2.32
5:20	192	112.9	1.72	38.7	104.9	184	113.9	1.91
5:22	192	112.9	1.72	39.2	104.9	188	114.3	1.85
5:24	200	113.4	1.97	40.2	107.9	196	113.9	1.95
5:26	207	113.4	2.07	39.7	106.9	203	114.	2.08
5:28	221	113.4	2.21	41.6	104.9	220	114.2	2.25
5:30	229	113.4	2.21	42.5	104.9	209	114.2	2.20
AV.	208.2	113.4	2.08	39.8	107.5	206.2	114.	2.13
5:32	243	113.4	2.21	42.5	104.9	224	114.	2.25
5:34	215	113.4	1.97	43.0	106.9	200	114.1	2.08
5:36	215	113.4	2.07	42.5	104.9	193	114.6	2.14
5:38	236	113.4	2.35	43.4	107.9	224	114.5	2.39
5:40	243	113.9	2.45	44.9	104.9	229	114.8	2.53
5:42	247	113.9	2.55	43.4	108.9	253	115.0	2.66
5:44	243	114.4	2.45	43.0	106.9	241	115.1	2.62
5:46	207	114.4	2.07	42.5	106.9	203	114.9	2.68
5:48	207	114.4	1.97	41.6	103.9	206	114.7	2.08
5:50	192	114.4	1.77	40.2	105.9	188	115.1	1.94
5:52	215	114.4	1.97	42.1	109.9	212	115	2.17
5:54	192	114.4	1.87	41.6	107.9	196	115.	1.95
5:56	200	114.4	1.77	42.1	104.9	181	115.3	1.95
5:58	200	114.4	1.72	42.5	105.9	187	115.5	1.91
6:00	215	114.9	1.97	42.1	106.9	212	116.2	2.15
AV.	218	114.1	2.08	42.4	106.2	210	114.8	2.23

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
6: 2	215	114.4	2.07	42.5	106.9	205	116	2.13
6: 4	221	114.4	2.12	43.4	105.9	212	116.1	2.22
6: 6	243	114.4	2.21	44.4	107.9	220	116.	2.91
6: 8	229	114.6	2.21	43.9	106.9	205	115.9	2.35
6:10	236	114.9	2.12	43.9	105.9	197	115.7	2.16
6:12	243	114.9	2.35	43.4	105.9	193	115.7	2.16
6:14	240	114.7	2.35	44.9	108.9	231	115.9	2.55
6:16	236	116.1	2.32	43.4	105.9	235	115.9	2.66
6:18	225	115.9	2.26	44.4	107.9	239	116.3	2.45
6:20	221	116.4	1.97	43.9	106.4	205	116.5	2.21
6:22	221	116.7	2.02	43.9	106.9	205	116.7	2.26
6:24	236	116.9	2.16	44.9	108.9	228	116.8	2.40
6:26	229	116.9	2.16	44.9	109.9	216	116.9	2.50
6:28	247	117.0	2.40	45.4	110.9	242	117.	2.51
6:30	251	117.4	2.40	48.7	111.9	243	116.9	2.85
AV.	232.4	116.	2.20	47.	107.8	218.1	116.1	2.38
6:32	265	117.4	2.50	46.8	107.9	239	116.9	2.60
6:34	284	117.4	2.26	45.8	109.9	239	117.1	2.59
6:36	254	117.4	2.50	46.8	112.9	250	117.1	2.85
6:38	262	117.4	2.60	46.8	112.9	250	116.9	2.95
6:40	229	115.6	2.07	45.4	108.9	227	116.9	2.80
6:42	236	115.7	2.40	45.4	108.9	226	117.4	2.60
6:44	243	115.5	2.26	45.6	109.4	243	117.	2.55
6:46	257	115.9	2.42	45.4	108.9	267	117.6	2.70
6:48	257	115.9	2.42	45.4	108.9	267	117.6	2.70
6:50	173	118.4	1.54	47.7	116.9	220	117.5	2.45
6:52	236	117.4	2.16	51.6	111.9	271	117.5	3.05
6:54	251	117.2	2.21	52.1	111.9	252	117.5	3.05
6:56	251	117.4	2.16	53.	109.9	252	117.7	3.10
6:58	247	117.4	2.17	53.1	109.9	267	117.6	3.08
7:00	251	117.4	2.18	52.1	108.9	269	117.8	3.12
AV.	240.1	117.1	2.20	48.4	110.2	246.1	117.4	2.80

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
7: 2	243	117.4	2.13	52.1	108.9	245	117.7	2.88
7: 4	243	117.4	2.13	51.1	108.9	245	117.7	2.89
7: 6	243	117.4	2.12	51.1	109.1	246	118.	2.88
7: 8	243	117.4	2.13	51.3	108.4	246	118.1	2.90
7:10	243	117.5	2.13	51.1	108.2	248	118.2	2.91
7:12	243	117.5	2.13	50.9	107.9	248	118.1	2.90
7:14	243	117.5	2.13	51.1	108.4	249	117.9	2.92
7:16	243	117.5	2.13	51.1	108.6	252	117.9	2.92
7:18	242	117.4	2.13	51.1	108.2	252	118.2	2.92
7:20	243	117.5	2.15	52.1	108.9	255	118.2	2.97
7:22	244	117.6	2.16	51.6	108.9	265	118.2	3.00
7:24	244	117.4	2.16	51.6	108.6	266	118.2	3.00
7:26	243	117.4	2.16	52.1	109.4	267	118.4	3.03
7:28	243	117.4	2.16	51.6	109.4	268	118.2	3.03
7:30	252	117.6	2.21	54.	107.9	252	118.2	3.01
AV.	243.8	117.5	2.14	51.5	108.4	253.9	118.1	2.94
7:32	253	117.6	2.21	55.	107.9	252	118.2	3.02
7:34	254	117.6	2.22	54	107.4	265	118.1	3.05
7:36	247	117.6	2.21	52.1	104.4	267	117.9	3.08
7:38	264	117.5	2.31	52.1	104.9	246	117.9	3.07
7:40	262	117.5	2.31	55.	107.9	243	117.9	3.10
7:42	265	117.6	2.28	52.1	104.9	246	118.2	3.07
7:44	259	117.5	2.27	51.6	104.9	244	118.	3.05
7:46	260	117.6	2.27	51.9	104.9	247	118.1	3.07
7:48	258	117.6	2.26	51.9	104.9	247	118.1	3.07
7:50	257	117.5	2.24	51.3	104.9	248	117.9	3.04
7:52	257	117.5	2.27	51.3	104.7	243	117.9	3.03
7:54	257	117.5	2.28	51.1	103.9	242	117.8	3.01
7:56	257	117.6	2.28	52.2	103.9	252	118.3	3.08
7:58	258	117.8	2.29	51.6	103.9	251	118.2	3.07
8:00	243	118.4	2.08	53.0	106.1	226	117.7	2.94
AV.	257	117.7	2.25	52.5	105	247.6	118.1	3.06

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PM. Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
8: 2	265	118.4	2.36	50.6	102.9	251	118.3	3.10
8: 4	229	117.3	2.14	51.1	98.9	278	117.7	2.93
8: 6	229	117.2	2.14	51.5	98.9	278	117.8	2.93
8: 8	229	117.4	2.14	46.5	98.4	278	117.8	2.95
8:10	229	117.1	2.13	46.2	97.9	276	117.5	2.92
8:12	229	117.2	2.14	46.7	98.9	274	117.7	2.92
8:14	230	117.3	2.15	46.7	98.4	272	117.5	2.92
8:16	232	117.1	2.14	46.4	98.2	274	117.7	2.93
8:18	231	117.2	2.15	46.6	98.4	275	117.6	2.93
8:20	232	117.3	2.16	47.3	99.9	274	118	2.97
8:22	235	117.4	2.17	47.0	98.9	282	117.9	2.99
8:24	236	117.4	2.17	47.2	98.9	281	117.8	3.00
8:26	236	117.4	2.17	47.2	98.9	284	117.9	3.00
8:28	236	117.4	2.16	47.7	100.9	278	117.8	2.97
8:30	236	117.4	2.13	47.6	100.9	288	117.8	3.03
AV.	234.1	117.4	2.16	47.8	99.2	276	117.9	3.00
8:32	237	117.4	2.21	47.	99.4	251	117.9	3.09
8:34	215	118.4	1.97	46.7	98.4	271	117.9	2.91
8:36	215	118.3	1.95	46.3	97.6	268	117.8	2.89
8:38	215	118.3	1.95	46.3	97.9	267	117.7	2.87
8:40	215	118.2	1.93	46.3	97.9	265	117.5	2.86
8:42	222	117.4	2.07	46.7	98.4	268	117.5	2.92
8:44	222	117.4	2.06	46.8	98.4	271	117.5	2.91
8:46	225	117.4	2.06	46.8	98.4	271	117.5	2.91
8:48	226	117.4	2.07	46.8	98.9	270	117.2	2.89
8:50	225	117.4	2.05	46.4	97.9	270	117.3	2.89
8:52	227	117.4	2.06	46.8	98.4	271	117.3	2.91
8:54	225	117.4	2.04	46.8	98.4	269	117.3	2.87
8:56	223	117.2	2.03	46.6	98.4	267	117.3	2.87
8:58	225	117.3	2.03	46.5	97.9	267	117.4	2.86
9:00	221	117.2	2.02	46.3	97.9	265	117.3	2.83
AV.	222.2	117.4	2 10	46.5	99.7	268	117.5	2.90

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
9: 2	221	117.2	2.03	46.6	97.9	261	117.2	2.83
9: 4	221	117.3	2.02	46.4	97.9	258	117.3	2.80
9: 6	227	117.2	2.08	47.3	99.9	282	117.2	3.03
9: 8	227	117.6	2.07	47.6	99.9	283	117.3	3.03
9:10	227	117.4	2.06	47.7	100.9	280	117.3	3.02
9:12	228	117.6	2.06	47.9	99.9	282	117.5	3.02
9:14	227	117.4	2.06	49.0	100.9	281	117.5	3.02
9:16	227	117.5	2.06	47.6	100.9	280	117.5	3.02
9:18	231	117.4	2.05	47.4	103.4	276	117.5	3.02
9:20	227	117.5	2.05	47.4	100.1	283	117.4	3.03
9:22	225	117.3	2.03	47.3	99.9	277	117.3	2.99
9:24	226	117.6	2.03	46.8	100.4	276	117.4	2.99
9:26	228	117.4	2.04	46.9	99.9	280	117.5	3.01
9:28	222	116.9	2.01	47.6	98.9	269	117.1	2.91
9:30	221	116.9	1.99	47.7	98.9	266	117.	2.90
AV.	225.8	117.3	2.02	47.5	98.9	276	117.3	2.78
9:32	226	117.4	2.03	47.6	100.1	275	117.4	2.98
9:34	221	117.	2.01	46.8	99.0	269	117.1	2.91
9:36	222	117.1	1.99	46.8	98.7	267	116.9	2.90
9:38	221	117.	1.99	47.1	99.0	266	117.	2.90
9:40	222	117	1.98	46.8	98.7	266	117.	2.89
9:42	220	116.9	1.97	46.8	98.4	266	117.4	2.89
9:44	220	116.9	1.99	46.9	98.7	266	117.	2.89
9:46	221	117	1.99	46.9	98.9	266	117.	2.88
9:48	220	116.9	1.97	46.8	98.7	266	117.1	2.89
9:50	221	117.2	1.99	47.0	99.0	268	117.3	2.90
9:52	220	116.9	1.98	46.9	99	266	117.5	2.90
9:54	221	116.9	1.97	46.9	98.9	266	117.5	2.89
9:56	215	116.9	1.94	46.8	99.9	272	117.5	2.88
9:58	212	116.9	1.92	45.8	100.4	266	117.5	2.81
10:00	215	116.9	1.91	45.9	100.7	266	117.5	2.72
AV.	219.6	117.	1.98	46.8	99.4	267.9	117.2	2.88

PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
10: 2	213	116.9	1.91	45.7	100.1	261	117.5	2.75
10: 4	211	116.8	1.90	45.5	99.9	257	117.3	2.77
10: 6	209	116.7	1.88	45.3	99.4	259	117.3	2.71
10: 8	209	116.7	1.86	45.1	98.9	257	117.3	2.72
10:10	208	116.7	1.86	45.1	98.7	256	117.3	2.70
10:12	207	116.5	1.92	45.9	99.9	246	117.	2.81
10:14	216	116.4	2.00	46.0	100.9	267	116.9	2.76
10:16	229	116.4	2.14	45.8	100.4	276	116.9	2.93
10:18	235	116.4	2.18	45.9	100.7	271	116.7	2.90
10:20	216	116.3	1.97	45.2	99.0	255	116.9	2.73
10:22	215	116.4	1.94	45.1	98.9	253	117	2.69
10:24	207	116.3	1.84	44.9	98.4	241	116.9	2.59
10:26	216	116.4	1.99	45.3	99.1	253	116.8	2.70
10:28	220	116.2	2.01	45.6	99.4	255	116.8	2.72
10:30	216	116.2	1.99	44.7	96.4	248	116.7	2.68
AV.	218	116.5	1.96	45.4	99.4	257	117.	2.74
10:32	203	116.2	1.80	44.4	96.6	229	116.7	2.49
10:34	230	117.	2.18	46.3	100.9	255	116.7	2.87
10:36	229	117.2	2.19	45.9	100.4	257	116.5	2.87
10:38	229	117.2	2.16	45.7	99.9	251	116.7	2.83
10:40	227	116.9	2.14	45.4	99.4	249	116.1	2.79
10:42	226	117.2	2.13	45.3	99.1	249	116.1	2.79
10:44	225	116.9	2.12	45.3	98.9	246	116.	2.77
10:46	225	116.9	2.11	46.3	100.7	242	115.7	2.75
10:48	235	116.9	2.54	45.8	99.9	257	115.9	2.89
10:50	221	116.6	2.05	45.0	98.6	242	115.9	2.89
10:52	220	116.9	2.04	44.9	98.4	238	115.9	2.65
10:54	218	116.9	2.02	44.8	98.1	236	116.	2.62
10:56	215	116.5	2.00	45.1	99.7	239	115.9	2.60
10:58	229	116.4	2.11	45.2	100.1	258	116	2.77
11:00	229	116.4	2.16	44.8	99.9	250	115.9	2.75
AV.	224.1	116.7	2.12	45.3	99.5	246	116.1	2.74

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
11: 2	207	116.4	2.39	44.9	98.9	223	115.8	2.54
11: 4	213	116.4	2.10	43.9	98.9	227	115.9	2.52
11: 6	213	116.1	1.97	44.4	97.4	226	115.7	2.49
11: 8	209	116.2	1.97	44.4	98.9	220	115.8	2.47
11:10	215	116.4	1.95	44.2	97.9	226	115.9	2.49
11:12	254	114.9	1.95	44.2	100.4	254	115.6	2.78
11:14	254	115.0	1.99	43.9	99.9	253	115.6	2.78
11:16	255	115.	2.47	45.5	100.9	250	115.6	2.77
11:18	240	114.9	2.47	45.5	98.9	224	115.6	2.56
11:20	239	114.9	2.47	45.5	98.9	223	115.7	2.53
11:22	236	114.7	2.26	44.8	98.4	229	115.7	2.51
11:24	236	114.6	2.24	44.5	98.4	227	115.6	2.49
11:26	247	114.5	2.22	44.3	99.9	244	115.5	2.67
11:28	246	114.7	2.20	44.5	99.4	249	115.4	2.71
11:30	227	114.9	2.38	45.0	96.9	220	115.5	2.37
AV.	233	115.3	2.20	44.6	98.7	233.1	115.6	2 58
11:32	229	114.4	2.10	43.9	97.4	219	115.1	2.40
11:34	220	114.4	2.09	43.9	96.9	217	115.3	2.35
11:36	237	114.3	2.23	44.5	97.9	230	115.1	2.51
11:38	236	113.4	2.54	45.9	99.9	228	115.3	2.51
11:40	261	113.4	2.54	44.6	98.4	240	116.2	2.62
11:42	246	113.6	2.34	44.4	97.9	224	115.9	2.42
11:44	244	113.4	2.33	44.2	97.9	222	116.	2.39
11:46	250	113.5	2.42	44.9	98.9	239	116.	2.50
11:48	254	113.4	2.45	44.9	99.4	235	116	2.56
11:50	254	113.4	2.45	44.9	99.4	235	115.9	2.54
11:52	240	113.4	2.57	44.1	97.6	217	115.9	2.32
11:54	240	113.4	2.20	44.0	96.9	217	115.9	2.31
11:56	233	113.2	2.13	43.4	95.9	207	115.5	2.20
11:58	231	113.2	2.12	43.4	95.9	205	115.5	2.19
12:00	229	113.1	2.12	43.6	96.1	202	115.3	2.15
AV.	234	113.5	2 31	44.3	97.8	225	115.7	2.39

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PM Time	W_1	V_1	A_1	I_F	E_F	W_2	V_2	A_2
12: 2	240	112.9	2.23	43.0	93.9	212	115.5	2.30
12: 4	168	111.9	1.63	39.2	103.9	184	115.2	1.62
12: 6	173	112.2	1.53	38.7	102.9	140	115.1	1.38
12: 8	171	112.2	1.52	38.7	102.7	138	115.1	1.37
12:10	207	110.9	1.83	39.7	104.4	135	115.1	1.47
12:12	199	110.9	1.72	39.7	103.9	146	114.9	1.42
12:14	196	111.	1.70	39.1	103.9	140	115.	1.40
12:16	208	110.9	1.97	39.7	105.4	169	114.9	1.62
12:18	211	110.9	1.94	39.7	105.7	170	115.	1.65
12:20	211	110.9	1.94	39.5	105.4	168	114.9	1.63
12:22	199	110.6	1.72	38.7	103.7	142	114.8	1.40
12:24	200	110.4	1.72	38.6	102.9	140	114.8	1.38
12:26	192	110.5	1.71	37.3	104.9	148	114.6	1.38
12:28	197	110.5	1.87	37.4	105.9	152	114.6	1.47
12:30	200	110.4	1.84	37.4	105.9	155	114.7	1.49
AV.	198.1	111.4	2.46	39 0	103.5	156	115.	1.55
12:32	182	110.8	1.65	37.2	104.9	133	114.5	1.26
12:34	182	110.7	1.64	37.1	104.4	131	114.6	1.26
12:36	168	110.6	1.52	36.9	103.9	123	114.6	1.15
12:38	184	110.6	1.67	37.3	104.9	140	114.6	1.34
12:40	182	110.6	1.67	37.3	104.9	140	114.	1.31
12:42	144	112.2	1.22	36.3	103.9	138	114.	1.21
12:44	131	112.4	1.18	36.1	103.1	109	114.3	1.01
12:46	131	112.4	1.18	36.1	103.1	106	114.	1.01
12:48	140	112.2	1.27	36.3	103.9	123	114.1	1.12
12:50	144	112.4	1.34	36.3	103.9	126	114.	1.20
12:52	144	112.3	1.34	36.3	103.9	125	114.	1.19
12:54	130	112.4	1.18	36.0	102.9	105	114	1.00
12:56	131	112.5	1.17	35.6	102.9	105	113.9	1.00
12:58	121	112.2	1.15	36.0	103.1	104	113.9	1.00
1:00	119	112.4	1.15	36.2	103.4	104	113.9	1.00
AV.	149	111.6	1.35	36.4	103.8	120.9	114.1	1.14

24 HOUR TEST.

Comparison of Switch Board Polyphase Wattmeter
with Results obtained by Power Measurement by two Wattmeter Method
using the Instrument Transformer.[1]

Time	W_1[1] Cor'ted.	K_1	Actual K. W.	W_2 Cor'ted.	K_2	Actual K. W.	K. W. Output	Polyphase Wattmeter
5: 6	207	837.8	173.4	224	825.4	184.8	358.2	350
5: 8	173	835	144.5	188	821.4	154.3	298.8	290
5:12	200	837.3	167.5	196	822.2	161.1	328.6	330
5:14	215	838.3	180.3	205	823.4	168.5	348.8	340
5:16	229	839.2	192.2	227	825.6	187.0	379.2	385
5:18	229	839.2	192.2	225	825.5	185.5	377.7	380
5:22	192	836.7	160.6	188	821.4	154.3	314.9	310
5:24	200	837.3	167.4	196	822.2	161.1	328.5	325
5:26	207	837.8	173.0	203	823.4	167.0	340.0	335

[1] This comparison can not be said to be absolutely reliable because it is almost impossible to read two indicating instruments at exactly the same instant. However, the indicating instruments used to measure the power during the test and the Polyphase wattmeter were read as nearly as possible at the same instant. Considering that the load was continually fluctuating, these values compare fairly well. The results would go to show that the Polyphase wattmeter reading is a little low.

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OUTPUT OF THE TURBO GENERATOR TAKEN EVERY HALF HOUR.

Time A. M. to P. M.	Corrected Av. R'dgs Watt-Meter No. 1 Weston #267	Constant K = Pri. Watts / Sec. Watts	Actual Primary K. W. W_1	Corrected Av. R'dgs Watt-Meter No. 2 Weston #2859	Constant K = Pri. Watts / Sec. Watts	Actual Primary K. W. W_2	Actual K. W. Output of gen. $W_1 + W_2$
1:00-1:30	206	838	172.5	168	818.4	137.6	310.0
1:30-2:00	170.8	834.5	141.8	136.5	812.7	110.7	252.5
2:00-2:30	147.2	832	122.4	118.8	809.5	96.2	218.6
2:30-3:00	136.5	830	113.4	111.0	807.6	89.7	203.1
3:00-3:30	134.1	830	111.3	108.5	807.2	87.6	198.9
3:30-4:00	124.5	827	102.7	96.1	804	77.2	179.9
4:00-4:30	129.5	829	107.5	99.9	805	80.4	187.9
4:30-5:00	125.1	828.5	103.5	96.4	804	77.5	181.0
5:00-5:30	119.0	826	98.2	101.1	805.2	81.3	179.5
5:30-6:00	129.5	829	107.5	101.5	805.2	81.7	189.2
6:00-6:30	103.0	825	85	85	802	68.2	153.2
6:30-7:00	142.5	831	118.5	119.5	809.5	96.7	215.2
7:00-7:30	172.9	835	144.2	158	817.0	129	273.2
7:30-8:00	201	837.5	168.3	179.2	820	146.8	315.1
8:00-8:30	215.8	838.5	181.0	192.8	821.7	158.5	334.5
8:30-9:00	202.2	837.5	169.0	190.0	821.5	156.0	325.0
9:00-9:30	204	837.7	171.0	192.2	821.7	157.7	328.7
9:30-10:00	190	836.5	159.0	190.0	821.5	156.0	315.0
10:00-10:30	212.8	838	178.5	204.5	823.3	168.3	346.8
10:30-11:00	220	838.4	184.5	211.6	824	174.0	258.5
11:00-11:30	214.8	838.4	180.0	207.5	823	170.7	358.7
11:30-12:00	209.9	838	176.0	202	823	166.0	342.0
12:00-12:30	218.0	836.8	183.0	203	823	167.0	350.0
12:30- 1:00	215.9	838.5	181.0	194.5	822	159.6	340.0
AV.			144.158		124.76		268.92

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OUTPUT OF THE TURBO GENERATOR TAKEN EVERY HALF HOUR.

P. M. to A. M.	Corrected Av. R'ds Wattmeter No. 1 Weston #267	Constant $K = \frac{\text{Pri. Watts}}{\text{Sec. Watts}}$	Actual Primary K. W. W_1	Corrected Av. R'd'gs Watt-Meter No. 2 Weston #2859	Constant $K = \frac{\text{Pri. Watts}}{\text{Sec. Watts}}$	Actual Primary K. W. W_2	Actual K. W. Output of gen. $W_1 + W_2$
1:00-1:30	206	837.8	172.5	193.8	821.5	159.3	331.8
1:30-2:00	199.5	837.3	167.2	187	821.3	153.5	320.7
2:00-2:30	218.2	838.6	183.0	211.5	824.0	174.4	357.4
2:30-3:00	208.8	823.0	175.0	207.4	823.4	171.0	346.0
3:00-3:30	215.5	832.4	180.7	206.2	823.4	170.0	350.7
3:30-4:00	229.9	839.0	193.0	199.8	822.8	164.5	357.5
4:00-4:30	230.0	839.0	193.0	203.4	823.0	167.5	360.5
4:30-5:00	215.8	838.4	181.0	193.8	822.6	159.3	340.3
5:00-5:30	208.2	838	174.5	206.2	823.5	169.8	344.3
5:30-6:00	218.0	838.6	183.0	210.0	824.0	173.0	356.0
6:00-6:30	232.4	839.4	195.0	218.1	824.8	180.0	375.0
6:30-7:00	240.1	839.6	201.5	246.1	827.3	204.0	405.5
7:00-7:30	243.8	839.8	204.7	253.9	828	210.0	414.7
7:30-8:00	257.0	840.4	215.5	247.6	827.5	205.0	420.5
8:00-8:30	234.1	839.4	196.5	276.0	829.6	229.0	425.5
8:30-9:00	222.2	838.8	186.3	268.0	829.2	222.5	408.8
9:00-9:30	225.8	839	189.5	276.0	829.6	229	418.5
9:30-10:00	219.6	838.7	184	267.9	829.2	222	406.0
10:00-10:30	218.0	838.7	183	257.0	828.2	213	396.0
10:30-11:00	224.1	839.0	188	246	827.3	203.5	391.5
11:00-11:30	233	839	195.5	233.1	826.3	192.5	388.0
11:30-12:00	234	839.4	196.4	225	825.5	185.7	382.1
12:00-12:30	198.1	837.2	165.7	156	816.3	127.5	293.2
12:30- 1:00	149	832	124.0	120.9	809.7	98.0	222.0
AV.			184.5			182.66	367.2

Av. Output for the total 24 hours = 318.056 x 24 K. W. H.

24 HOUR TEST
AUXILIARY STEAM CONDENSED PER HOUR.

Time	#Steam from Terry Exciter unit	#Steam from vacuum pump	#Steam from feed pumps	#Steam condensed in trap	Total auxiliary steam lbs.
1:00 - 2:00	1596.0	300	500.5	50	2457.5
2:00 - 3:00	1586.0	400	463.5	50	2499.5
3:00 - 4:00	1557.0	300	362.0	50	2269.0
4:00 - 5:00	1587.0	300	445.0	50	2382.0
5:00 - 6:00	1586.5	400	407.	50	2443.5
6:00 - 7:00	1561.0	400	374.	50	2385.0
7:00 - 8:00	1579.0	300	441.	50	2370.0
8:00 - 9:00	1578.0	400	490.5	50	2518.5
9:00 -10:00	1571.0	300	422.5	50	2343.5
10:00-11:00	1590.0	300	391.0	50	2331.0
11:00-12:00	1571.5	400	443.5	50	2465.0
12:00- 1:00	1598.5	300	402.5	50	2351.0
1:00- 2:00	1598.5	300	406.75	50	2355.25
2:00- 3:00	1587.5	400	422.5	50	2460.0
3:00- 4:00	1578.5	300	432.0	50	2360.5
4:00- 5:00	1583.0	400	383.5	50	2416.5
5:00- 6:00	1677.0	300	490.5	50	2517.5
6:00- 7:00	1713.0	389	504	50	2656.0
7:00- 8:00	1735.0	300	440	50	2525.0
8:00- 9.00	1683.5	300	466	50	2499.5
9:00-10.00	1672.	403	471	50	2596.0
10:00-11:00	1670	320	465	50	2505.0
11:00-12:00	1644.5	400	461	50	2555.5
12:00- 1:00	1620.5	390	343	50	2403.5
Totals	38,724.5	8302	10439.25	1200	58,665.75

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FEED WATER, TOTAL AUXILIARY STEAM, AND STEAM CONSUMPTION OF THE TURBINE PER HOUR

Time	Boiler feed lbs.	Total Lbs. auxiliary steam	#Steam consumed by turbine	Temp. of boiler feed °F
1:00 - 2:00	19870	2457.5	17412.5	89.6 °F
2:00 - 3:00	13641	2499.5	11141.5	98
3:D0 - 4:00	8558	2269.0	6289.0	102.8
4:00 - 5:00	13046	2382.0	10664.0	110.2
5:00 - 6:00	10136	2443.5	7692.5	111.7
6:00 - 7:00	8140	2385.0	5755.0	107.8
7:00 - 8:00	14714	2370.0	12344.0	108.5
8:00 - 9:00	16094	2518.5	13575.5	106.9
9:00 -10:00	11688	2343.5	9344.5	108.
10:00 -11:00	10231	2331.0	7900.0	112.8
11:00 -12:00	13761	2465.0	11296.0	113.5
12:00 - 1:00	14212	2351.0	11861.0	108.2
1:00 - 2:00	12371	2355.25	10015.75	101.1
2:00 - 3:00	15678	2460.0	13218.0	102.8
3:00 - 4:00	16863	2360.5	14502.5	103.5
4:00 - 5:00	12081	2416.5	9664.5	101.9
5:00 - 6:00	14420	2517.5	11902.5	105.2
6:00 - 7:00	12279	2656.0	9623.0	108.3
7:00 - 8:00	12007	2525.0	9482.0	114.0
8:00 - 9:00	16103	2499.5	13603.5	113.5
9:00 -10:00	17584	2596.0	14988.0	105.
10:00 -11:00	16436	2505.0	13931.0	107.
11:00 -12:00	15932	2555.5	13376.5	109.7
12:00 - 1:00	14138	2403.5	11734.5	111.5
Totals	329,983	58,665.75	271,317.25	102.4 AV.

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24-HOUR TEST.

STEAM CONSUMPTION PER K. W. HR. TAKEN FOR EACH HOUR PERIOD.

Time AM	AV. K. W. Output Of the Turbo-Generator.	Steam Consumed By the Turbine	Wet Steam Consumed per K.W. Hr.	Dry Steam Consumed per K.W. Hr.
1:00 - 2:00	281.3	17,412.5	61.90#	60.60 #
2:00 - 3:00	210.85	11,141.5	52.80	51.80
3:00 - 4:00	189.40	6,289.0	33.20	32.41
4:00 - 5:00	184.45	10,664.0	57.80	56.40
5:00 - 6:00	184.35	7,692.5	41.70	40.75
6:00 - 7:00	184.20	5,755.0	31.25	30.65
7:00 - 8:00	294.15	12,344.0	41.90	41.35
8:00 - 9:00	332.25	13,575.5	40.80	40.10
9:00 -10:00	321.85	9,344.5	29.05	28.50
10:00-11:00	352.65	7,900.0	22.40	21.95
11:00-12:00	346.35	11,296.	32.60	32.00
12:00- 1:00	345.30	11,861.	34.40	33.70
Totals		125,275.5		
AV.	268.92		39.94	39.18

Av. Steam consumption per K. W. Hr. taking the average values for the full 12 hrs. 1 A. M. to 1 P. M. = 38.8# of wet steam.

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24-HOUR TEST.

STEAM CONSUMPTION PER K. W. HR. TAKEN FOR EACH HOUR PERIOD.

Time PM	AV. K. W. Output of the Turbo-Generator	Steam Consumed by the Turbine	Wet Steam Consumed per K. W. HR.	Dry Steam Consumed per K. W. HR.
1:00 - 2:00	326.25	10,015.75	30.7	30.10
2:00 - 3:00	351.70	13,218.00	37.62	37.00
3:00 - 4:00	354.10	14,502.5	40.95	40.25
4:00 - 5:00	350.40	9,664.5	27.55	27.05
5:00 - 6:00	350.15	11,902.5	34.01	33.30
6:00 - 7:00	390.25	9,623.0	24.65	24.20
7:00 - 8:00	417.60	9,482.0	22.75	22.25
8:00 - 9:00	417.15	13,603.5	32.70	32.05
9:00 -10:00	412.25	14,988.0	36.41	35.80
10:00 -11:00	393.75	13,931.	35.41	34.80
11:00 -12:00	385.05	13,376.5	30.45	29.85
12:00 - 1:00	257.60	11,734.5	45.5	44.60
Totals		146,041.75		
AV.	567.2		33.18	32.604

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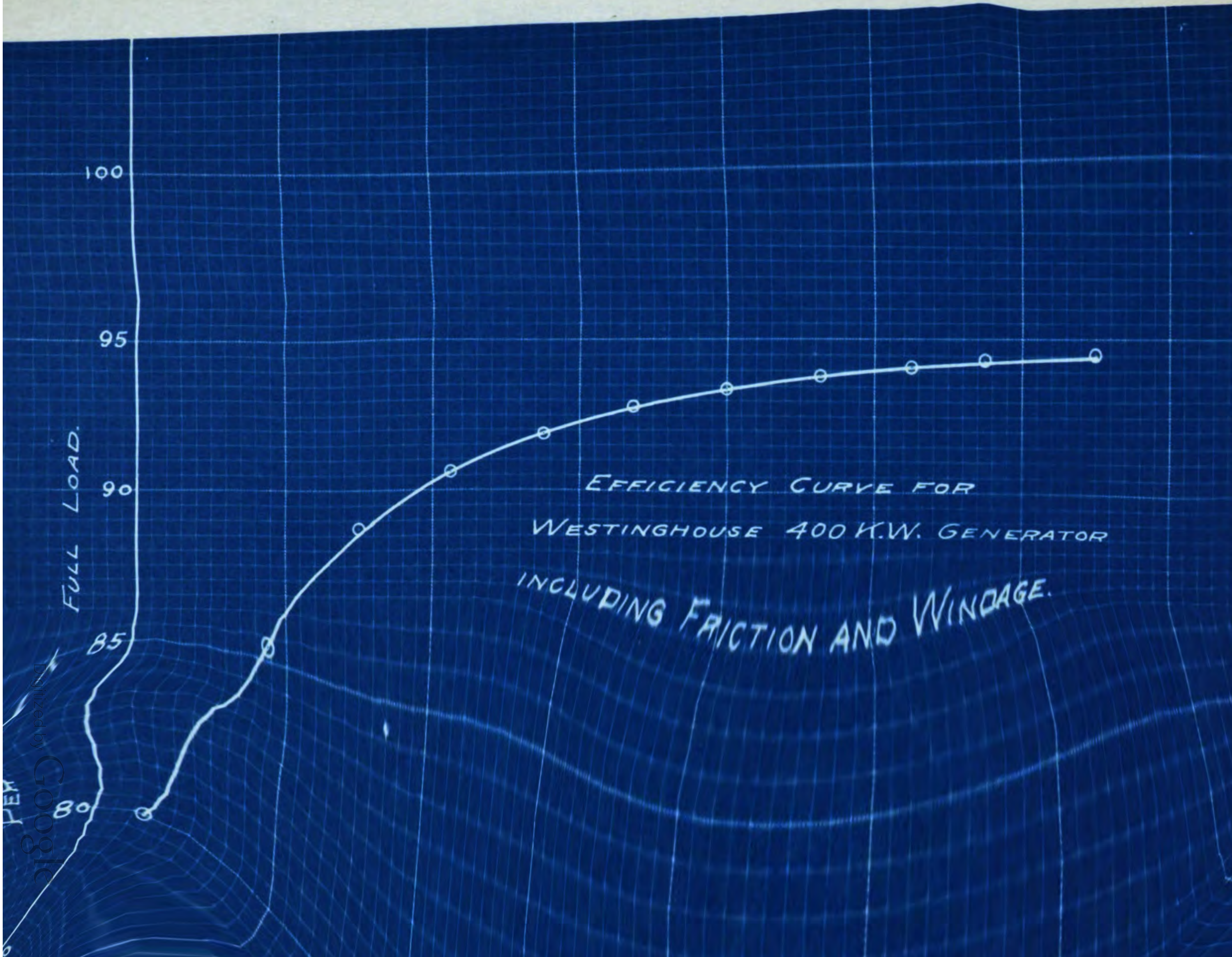
Efficiency Curve for
Westinghouse 400 K.W. Generator
including Friction and Windage.
100
95
90
85
80
Full Load.

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24-HOUR TEST.
STEAM CONSUMPTION.

Time	K. W. Output Average	Eff. of Generator	B. H. P. of Turbine	Total Steam Consumed Lbs.	Lbs. Wet Steam per K.W. HR.	Lbs. Wet Steam per B.H.P. HR.
1:00 AM to 1:00 PM	268.92	91.1 %	395.7	125.275	38.8	26.4
1:00 PM to 1:00 AM						
1:00 PM to 1:00 AM	318.05	92.3 %	462.2	271.317	35.6	24.6

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Discussion of Results.

The Average load for the 24 hours was 318.06 K. W. or 79.55% Full load.

The steam consumption per K. W. hr. and per B. H. P. hr. was computed for each 12-hour period, and also the av. steam consumption per K. W. hr. and per B. H. P. hr. for the full twenty-four hour period.

An attempt was made to determine the steam consumption for various loads of the turbine by taking periods of one or two hours over which the load remained fairly constant. This attempt, however, proved a failure due to the fact that it was impossible to check up the actual amount of steam consumed during any short period of time. This is readily seen when one considers that a matter of from 2000 to 4000 pounds of water can scarcely be noticed on the boiler water level when the boiler is in actual operation.

In order to obtain the exact steam consumption of the turbine by the method used, it would be necessary to use a boiler which had a rather small water surface in the boiler at the water level. As the boiler used was rather large it was impossible to get the exact steam consumption of the turbine using a jet condenser.

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A heat balance for the whole plant, which shows when the heat from the coal is distributed, was determined and the results plotted graphically using the Heat units in the combustible as 100 H. U. and all the heat distributed through the plant as proportional parts of the heat in the combustible.

The total amount of Condensing water used by the jet condenser was computed from the steam consumed by the turbine, and the rise in temperature of the condensing water.

The Average amount of condensing water was found to be 329,000 lbs. of water per hour.

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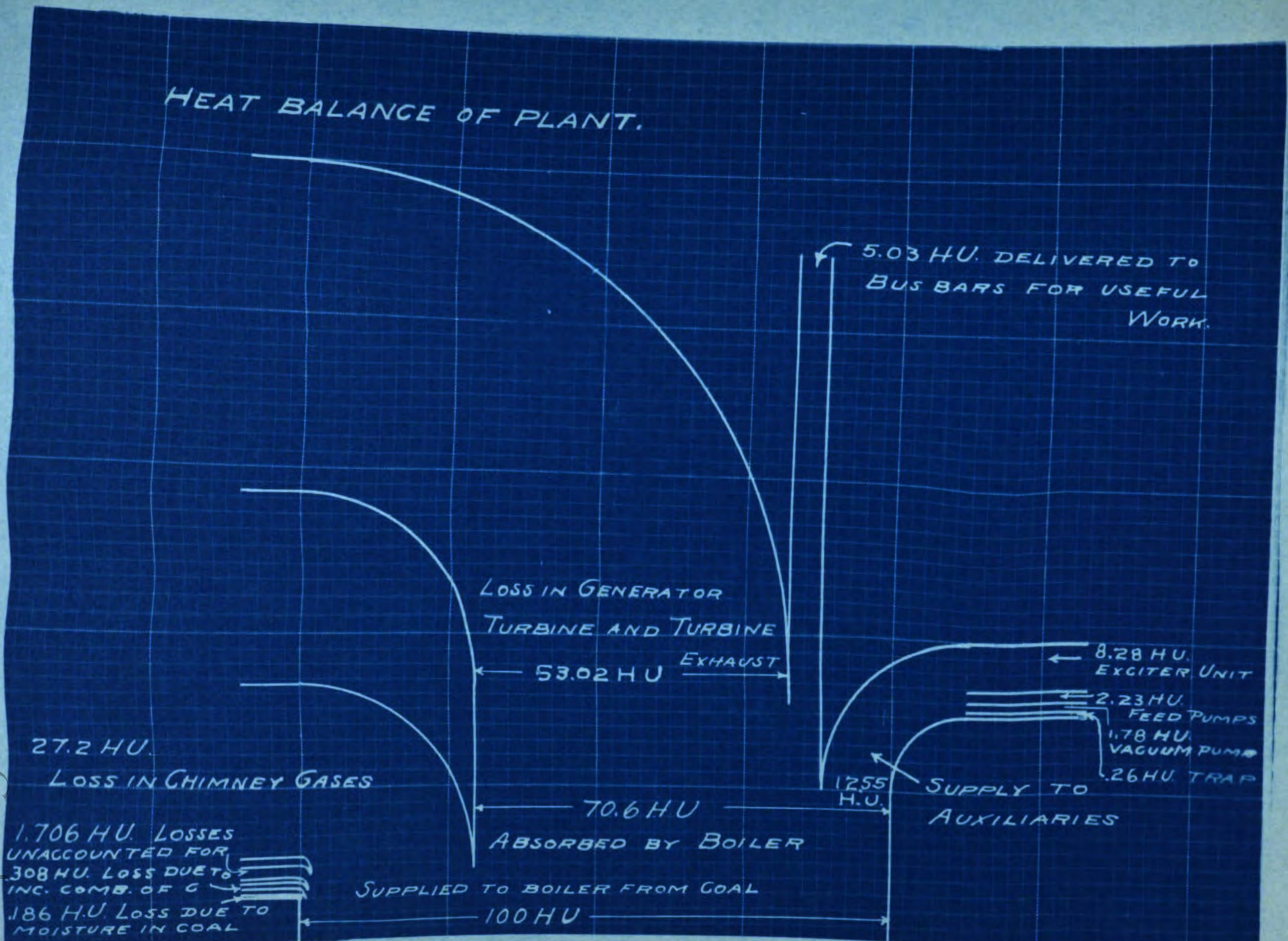

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12-Hour Boiler Test on Stirling Boiler.

Object.

In view of the fact that on the 24-hour turbine and boiler test the boiler was not loaded to its full capacity and that on account of the inconvenience of bringing the coal to the boiler room so that the amounts fired could be checked for two hour intervals, it was thought advisable to run this 12-hour boiler test.

Method.

As it was impossible to start the fire at the beginning of the test and pull it at the end, the test was ended with the bed of fire in practically the same condition as when the test was started. The ash pit was clean at the beginning and end of the test so that all of the ash and refuse removed from the ash pit was the result of coal fired to the grates. The amounts of coal fired to the boiler were checked for two-hour intervals.

Boiler pressure was read on a Bourdon gauge on top of the boiler. Steam quality readings were obtained by the use of a throttling calorimeter located near the pressure gauge and on the same pipe.

Stack temperatures were obtained by use of a

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calibrated thermo-couple and the flue gas was analyzed with an Orsat apparatus.

Pressure across the grates was measured with a manometer, one arm of which was subjected to atmospheric pressure, and the other to the pressure above the grates. Chimney draft was measured with a differential oil draft gauge. One arm of this gauge was free to the atmosphere, while the other was subjected to the pressure within the stack. This last pressure was obtained by connecting the draft gauge through the hole formed by removing the handle from the middle door in the boiler breaching.

The boiler feed water was pumped from the feed water heater to one of two weighing tanks of about 1200 pounds capacity each. From these tanks the water passed by the force of gravity into the hot well, a tank of about 2500 pounds capacity, and from there it was pumped by a second reciprocating boiler feed pump into the boiler. Boilerfeed water temperatures were taken in the hot well. The amounts of boiler feed water furnished to the boiler were noted each hour. Whenever a check was made the level of the water in the boiler was the same and the level of the water in the hot well, as determined by means of a float, was the same.

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<u>Conclusions</u>.

Due to the fact that the coal fired was of a poor quality, it was hard for the fireman to keep a uniform bed of fire, under the fluctuating load on the boiler during the test. In consequence of this circumstance, it is feasible to assume that not all of the coal fired during a two hour interval was used to evaporate the water fed to the boiler during that interval, and that part of the coal fired during one two hour interval may have been used to evaporate some of the boiler feed water fed in the succeeding two hour interval. This conclusion is drawn because the pounds of water evaporated per pound of coal does not remain constant. The non-uniformity of the coal is also an influencing factor, but its immediate effect could only be approximated by an infinite number of analyses of the coal and this would be impracticable.

It should also be noted, that it is impossible to accurately read the height of water in the boiler, due to the large surface area of thewater in the boiler. One thousand pounds of water added to the boiler would make a difference in the boiler water level which could hardly be noticed. Hence, the fact that the pounds of water evaporated per pound of coal does not remain constant, is also due in part

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to the inevitable inaccuracy of reading the boiler level at times of checks.

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BOILER TEST DATA.
BOILER FEED WATER.

Time	Pds. of Water Fed	Temp. of Feed Water in F°	Time	Pds. of Water Fed	Temp. of Feed Water
7 - 8 AM.	1287		9 - 10 AM	1249	
	1247	181		1228	
	1270			1285	
	1281			1280	
	1263			1247	
	1281			1263	182
	1229			1234	
	1208			1273	
	1181	181		1105	183
	1182			1178	
	1224			1211	
	1262	183		1185	
	926			1190	
	Sum = 15841	Av. = 182°F		1171	
				1307	
8 - 9 AM.	1235			1295	
	1286			700	
	1245	182		Sum = 20402	Av. = 182.5
	1271				
	1254				
	1249				
	1250	183			
	1080				
	1185	182			
	1198				
	1160				
	1175	182			
	1135				
	1190				
	1198				
	Sum = 18211	Av. = 182.25			

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BOILER TEST DATA.

BOILER FEED WATER

Time	Pds. of Water Fed	Temp. of Feed Water in F	Time	Pds. of Water Fed	Temp. of Feed Water
10 - 11 AM	1215		11 - 12 AM	1012	184
	1238	184		1205	190
	1231			1260	190
	1188			1256	188
	1211	188		1172	
	1226	190		1180	
	1172	192		1175	
	1153	188		1248	
	1204			1259	
	230			1167	188
	583			1100	192
	1287			1174	192
	1118			1115	
	999			1304	
	1226	190		1256	
	925			1109	190
	886	190		1271	
	1067	192	Sum =	20219	Av. = 189.25
	1088				
	1263				
Sum =	21510	Av. = 189.45			

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BOILER TEST DATA.

BOILER FEED WATER.

Time	Pds. of Water Fed	Temp. of Feed Water in F^{o}	Time	Pds. of Water Fed	Temp. of Feed Water
12 - 1 PM	1132	190	1 - 2 PM	1275	190
	1197	186		1168	
	1125	192		1253	188
	1124			1192	
	1213			1201	190
	1262	186		1219	
	1157			1237	
	1261			1250	
	1189	186		1226	190
	1062	188		1183	190
	1282			1266	
	1199			1207	190
	1232			1261	
	1175			1193	192
	1260	192		1189	
	1183	190		1189	
	Sum = 19053	Av. = 188.75		Sum = 19509	Av. = 189.9

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BOILER TEST DATA.
BOILER FEED WATER.

Time	Pds. of Water Fed	Temp. of Feed Water in F°	Time	Pds. of Water Fed	Temp. of Feed Water
2- 3 PM	1202		3 - 4 PM	712	190
	1204			1166	
	1204	190		1164	190
	1276	184		1167	
	1188			1226	
	1282			1204	
	1146			1224	192
	1227			1180	192
	520			1268	
	1190	190		252	
	1184			1177	190
	1289			1179	
	1177	190		1187	
	1158			1186	190
	1206			1194	
	1276			1184	192
	1194			1258	
	1179	192		1282	
				476	
	Sum = 21102	Av. = 188.8		Sum = 20686	Av. = 190.85

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BOILER TEST DATA.
BOILER FEED WATER.

Time	Pds. of Water Fed	Temp. of Feed Water in F°	Time	Pds. of Water Fed	Temp. of Feed Water
4 - 5 PM	704	191	5 - 6 PM	1258	178
	1211	192		1183	180
	1183			1129	184
	1296	178		1172	184
	1204	184		1196	186
	1165	180		1185	190
	1146	174		1311	188
	1126	174		1239	186
	1267	192		1187	180
	1179			1261	184
	1193	192		1191	184
	1216	180		1199	186
	1208	186		1205	186
	1294	174		1275	188
	1196	174		1212	186
	828	176		595	
	Sum = 18416	Av. = 182		Sum = 18798	Av. = 184.75

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BOILER TEST DATA.
BOILER FEED WATER.

Time	Pds. of Water Fed	Temp. of Feed Water in F°
6 - 7 PM	1182	188
	1180	190
	1131	190
	1168	
	1153	
	1127	190
	1186	
	1129	
	605	188
	1191	190
	1190	
	1285	
	1177	188
	1193	
	1193	190
	1258	190
	513	
	Sum = 18861	Av. = 189.35

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BOILER TEST DATA.

TIME	% CO_2	% O_2	% CO		TIME	% CO_2	% O_2	% CO
7.30	4.0	14.1	0.9		1.30	6.6	12.8	0.4
8.00	5.0	14.0	0.3		2.00	6.8	12.6	0.2
.30	6.0	13.4	0.1		.30	7.2	12.0	0.2
9.00	6.1	13.2	0.2		3.00	8.6	10.0	0.2
.30	6.0	13.0	0.4		.30	3.8	15.6	0.2
10.00	5.8	13.2	0.3		4.00	8.2	11.0	0.3
.30	6.0	12.8	0.4		.30	4.2	14.4	0.4
11.00	6.2	12.3	0.5		5.00	7.2	12.2	0.2
.30	6.8	11.6	0.6		.30	6.0	13.1	0.4
12.00	6.4	11.6	0.5		6.00	6.4	12.8	0.2
.30	6.0	13.2	0.3		.30	7.0	12.4	0.2
1.00	6.2	13.1	0.3		7.00	6.8	12.5	0.2

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BOILER TEST DATA
CALORIMETER DATA

Time	Temp. in Degrees Fahr.	Back press. in inches of Mercury	Boiler press in lbs. per sq. inch	% dry Steam
7:30	279	2.4	150	98.15
45			148	
8:00	280	2.4	152	98.1
15			151	
30	278	2.5	148	98.3
45			146	
9:00	276	2.3	141	98.2
15			146	
30	278	2.6	149	98.2
45			147.5	
10:00	278	2.5	148	98.3
15			147.5	
30	278	2.6	152	98.2
45			152	
11:00	279	2.5	145	98.3
15			147	
30	278	2.7	152	98.2
45			132	
12:00	279	2.5	145	98.3
15			147	
30	280	2.5	142	98.4
45			143	
1:00	279	2.6	150	98.2
15			157	

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BOILER TEST DATA
CALORIMETER DATA

Time	Temp. in Degrees Fahr.	Back press. in Inches of Mercury	Boiler press. in Lbs. per sq. inch	% dry Steam
1:30	279	2.6	147	98.3
45			146	
2:00	279	2.5	143	98.2
15			150	
30	278	2.4	141	98.2
45			145	
3:00	278	2.5	148	98.1
15			145	
30	278	2.1	118	97.8
45			145	
4:00	279	2.6	150	98.3
15			143	
30	274	2.2	128	98.1
45			152.5	
5:00	278	2.6	150	98.1
15			140	
30	279	2.4	144	98.25
45			147	
6:00	279	2.5	145	98.3
15			147.5	
30	278	2.6	147	98.2
45			150	
7:00	278	2.6	140	98.3

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BOILER TEST DATA.

Time	Pds. of Coal Burned	Pds. of Ash Removed	Chimney Draft in Inches of H_2O	Draft Across Grates in Inches of H_2O	Chimney Temp. in Milli-Volts	Chimney Temp. in Fahr. Degrees
7.00	4768		.86			
.15			.91			
.30			1.00		2.0	422
.45					1.9	410
8.00			.95		2.0	422
.15			.98		1.95	415
30					1.95	415
45					2.0	422
9.00	4675		.80	.70	2.0	422
15					2.0	422
30			.78		2.0	422
45			.80	.68	2.0	422
10.00					2.0	422
15			.78	.63	2.0	422
30					2.0	422
45			.74	.60	1.95	415
11.00	5448		.67	.65	1.98	420
15				.62	1.98	420
30			.78	.62	1.95	415
45		372	.65	.61	1.80	393
12.00			.73	.61	2.0	422
15		327	.73	.62	1.99	421
30			.65	.61	1.9	410
45			.72		1.9	410
1.00	5131		.78	.60	1.92	410
15			.70	.55	1.9	410
30			.70	.60	1.9	410
45			.70	.60	1.95	415
2.00			.75	.63	1.98	420

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BOILER TEST DATA.

Time	Pds. of Coal Burned	Pds. of Ash Removed	Chimney Draft in Inches of H_2O	Draft Across Grates in Inches of H_2O	Chimney Temp. in Milli-Volts	Chimney Temp. in Fahr. Degrees
2.15			.73	.63	2.0	422
30			.77		1.9	410
45			.75	.56	1.9	410
3.00	5205		.77	.53	1.96	417
15		3219	.75		1.94	413
30			.73	.60	1.75	387
45			.75	.70	1.9	410
4.00			.70	.55	1.98	415
15			.75		1.9	410
30			.65	.55	1.89	408
45			.65		2.0	422
5:00	4837		.65	.55	2.0	422
15			.66	.55	2.0	422
30			.70	.50	2.0	422
45			.65	.55	1.96	417
6.00			.65	.50	1.8	393
15			.65	.50	1.9	410
30			.67	.55	1.95	415
45			.67	.60	1.95	415
7.00		1188	.68	.55	1.98	415

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FUEL ANALYSIS 12-HOUR BOILER TEST.

Heating Value of Fuel. (Determined with Parr Calorimeter).

Heating Value.

Per lb. of coal as fired	11630
Per lb. of dry coal	12080
Per lb. of combustible	13620

Proximate Analysis of Coal.

% moisture	3.5
% volatile matter	35.5
% fixed carbon	49.5
% ash	11.5

Analysis of Ash and Refuse.

% volatile matter	3.0
% carbon	7.5
% earthly matter	89.5

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DATA AND RESULTS OF 12-HOUR BOILER TEST.

Average Pressure.	7 - 9	9 - 11	11 - 1	1 - 3	3 - 5	5 - 7
Steam pressure by gauge in lbs.	148	148.4	144.8	146.4	141.4	145
Draft in chimney in inches of water.	.89	.75	.72	.73	.59	.67
Draft across grates in inches of water.	**.70**	**.64**	**.61**	**.59**	**.59**	**.54**
Average Temperatures.						
Boiler feed water - deg. F	182.12	185.97	189.00	189.35	186.42	187.05
Flue gas temp. - deg. F	418	421	413	416	411	414
Flue Gas Analysis.						
% CO_2	5.3	6.0	6.35	7.3	5.85	6.55
% O_2	13.67	12.82	12.37	11.85	13.30	12.70
% CO	.375	.400	.425	.250	.275	.250
Fuel per Hour.						
Pds. dry coal consumed per hr.	2300	2255	2638	2480	2512	2335
Pds. coal fired per hr.	2384	2338	2724	2565	2603	2419
Pds. combustible consumed per hr.	**1981**	**1942**	**2259**	**2130**	**2158**	**2008**
Pds. ash removed	805	791	930	869	889	822
Pds. dry coal per sq. ft. of grate surface per hour	26.10	25.65	29.95	28.20	28.58	26.50
Pds. combustible per sq. ft. grate surface per hour	**17.95**	**17.61**	**20.45**	**19.25**	**19.47**	**18.18**

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DATA AND RESULTS OF 12-HOUR BOILER TEST - Continued.

Quality of Steam.	7 - 9	9 - 11	11 - 1	1 - 3	3 - 5	5 - 7
% dry	98.19	98.25	98.28	98.20	98.08	98.26
Water.						
Total weight of water fed boiler - lbs.	34052	41912	39272	40611	29102	37659
Equiv. water fed from and at 212 deg. F - lbs.	37000	45000	42070	43505	42050	40500
Water actually evap. corr for quality - lbs.	33500	41100	38600	39660	38380	37080
Factor of Evaporation	1.082	1.079	1.077	1.077	1.079	1.078
Equiv. evap. from and at 212 deg. F - lbs.	36300	44390	41530	43000	41280	39950
Water per Hour.						
Water Evap./hour corr.for quality - lbs.	16750	20550	19300	19980	19190	18540
Equiv. Evap./hour from and at 212 deg. F - lbs	18150	22195	20765	21500	20640	19975
EQuiv. Evap. from and at 212 deg. F/sq. ft. of water heating surface - lbs.	3.607	4.40	4.12	4.27	4.10	3.965
Horse Power						
Horse power developed	525.5	642.0	600.5	623.0	599.5	578.0
% Rated horse power	105.1	128.4	120.1	124.75	119.9	115.6
Economic Results.						
Water apparently evap.per lb. of coal underactual conditions as fired	7.14	8.96	7.20	7.90	7.52	7.80
Equiv. Evap. from and at 212 deg. F/lb.coal as fired	7.60	9.50	7.60	8.37	7.94	8.26

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Economic Results Continued	7 - 9 AM	9 - 11	11 - 1 PM	1 - 3	3 - 5	5 - 7
Equiv. Evap. from and at 212° F/lb. dry coal — lbs.	7.90	9.85	7.86	8.66	8.23	8.55
Equiv. Evap. from and at 212° F/lb. of combustible — lbs.	9.15	11.40	9.19	10.10	9.60	9.95
Efficiency.						
% Efficiency of boiler; heat absorbed by the boiler per lb. of combustible divided by the heat value of one lb. of combustible	64.9	81.0	65.3	71.8	67.8	70.5
	Average Efficiency 7 AM to 7 PM = 70.2 %					
% Efficiency of boiler, including the grate; heat absorbed by boiler, per lb. of dry coal fired divid. by the heat value of one lb. of dry coal.	62.9	78.4	62.8	69.0	65.4	68.0
	Average Efficiency 7 AM to 7 PM = 67.8 %					

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HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE IN THE 12-HOUR BOILER TEST.

Total Heat Value of 1 lb. of Combustible = 13620 B. T. U.

	B. T. U.	%
1. Heat absorbed by the boiler = Evaporation from and AT 212° F per lb. of combustible x 965.7	9560	70.2
2. Loss due to moisture in coal = % of moisture referred to combustible ÷ 100 x $[(212 - 85) + 966 + 0.48\,(416 - 212)]$. Negligible.		
3. Loss due to heat carried away in the dry chimney gases = wt. of gas/lb. of combustible x 0.24 x (416 - 85).	3000	22.0
4. Loss due to incomplete combustion of carbon = $\frac{CO}{CO_2 + CO} \times \frac{\%\ C\ \text{in combustible}}{100} \times 10{,}150$	203	1.5
5. Losses due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, to moisture formed by burning of hydrogen and other losses not accounted for	857	6.3
		100 %

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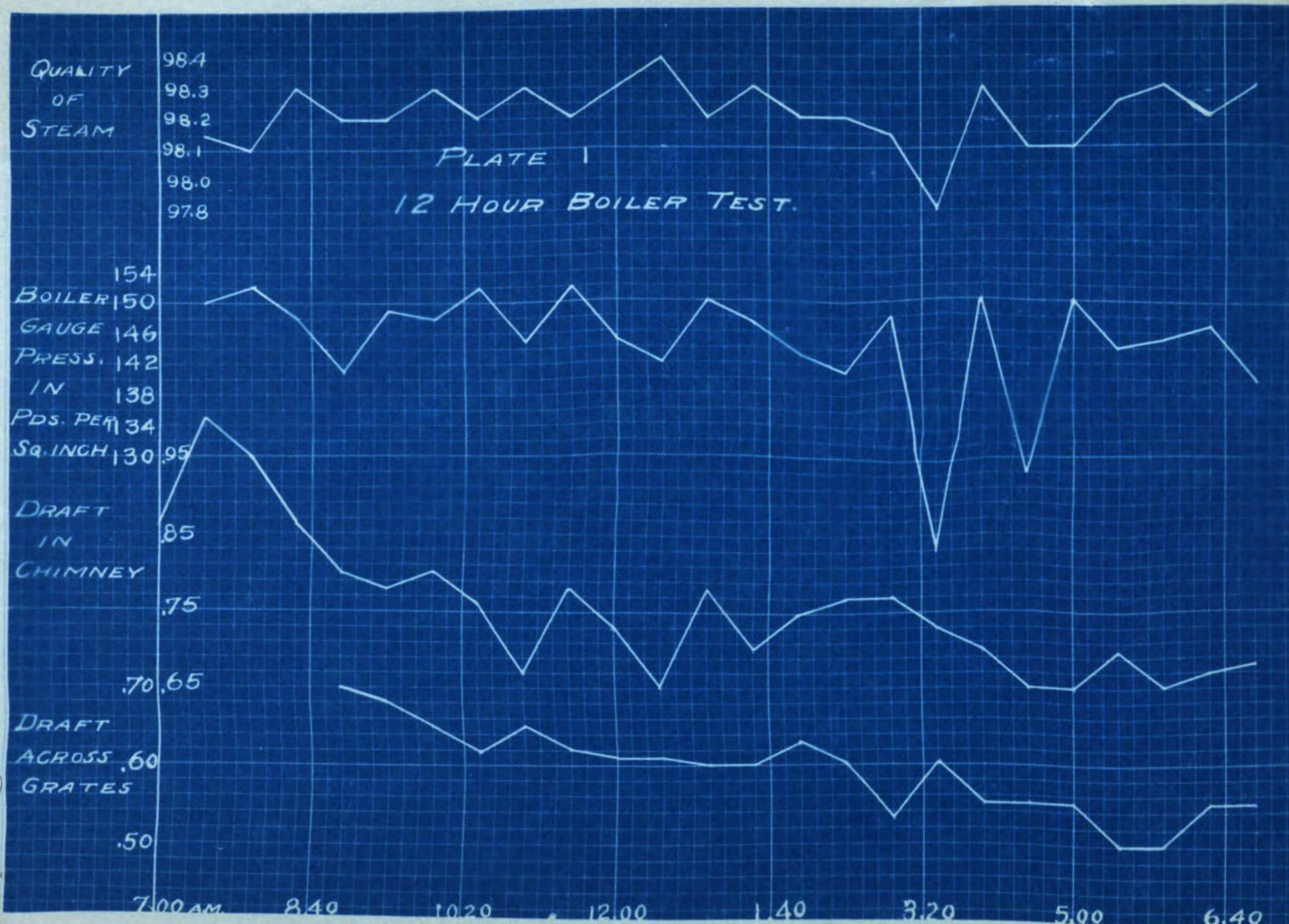

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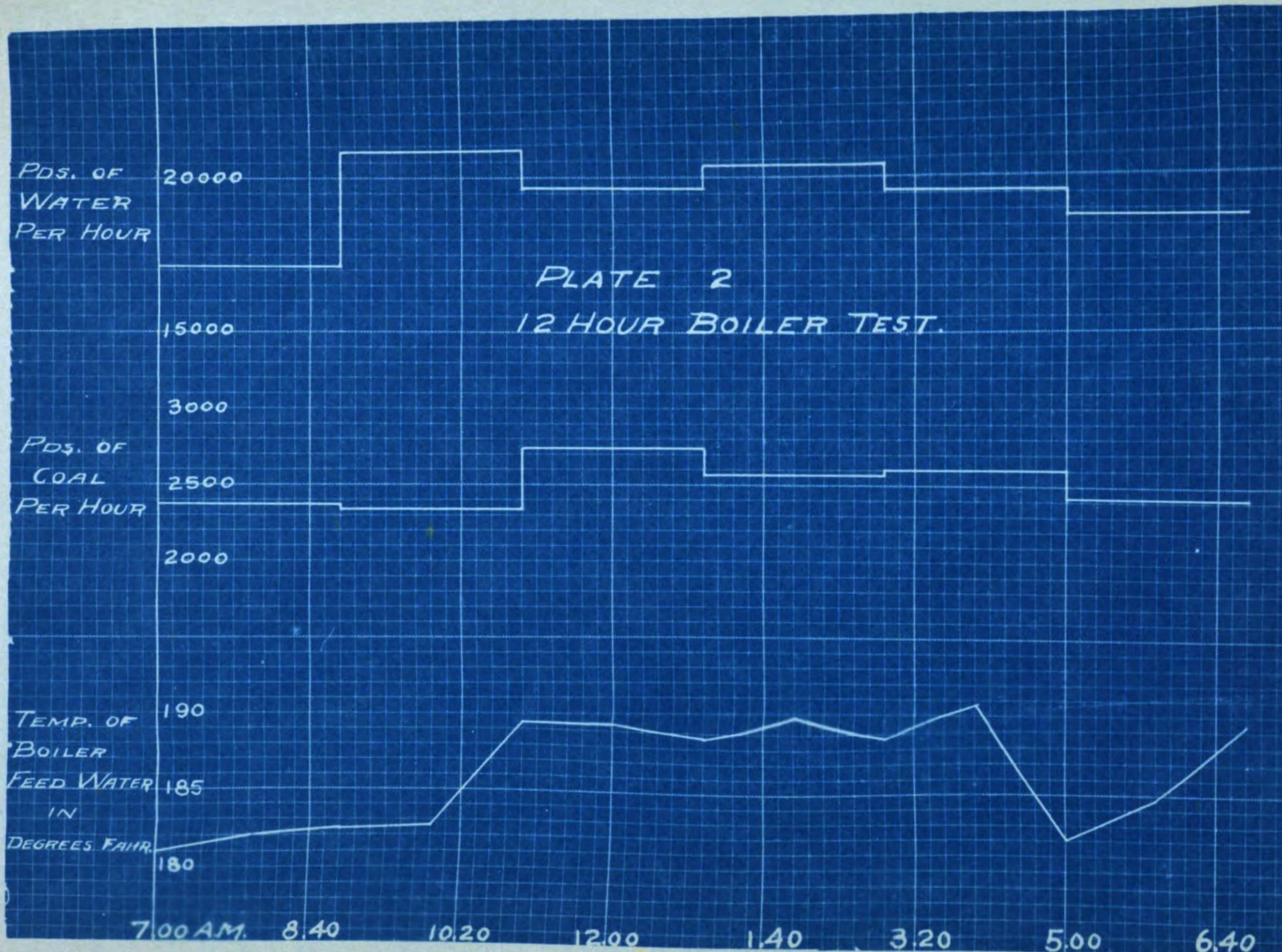

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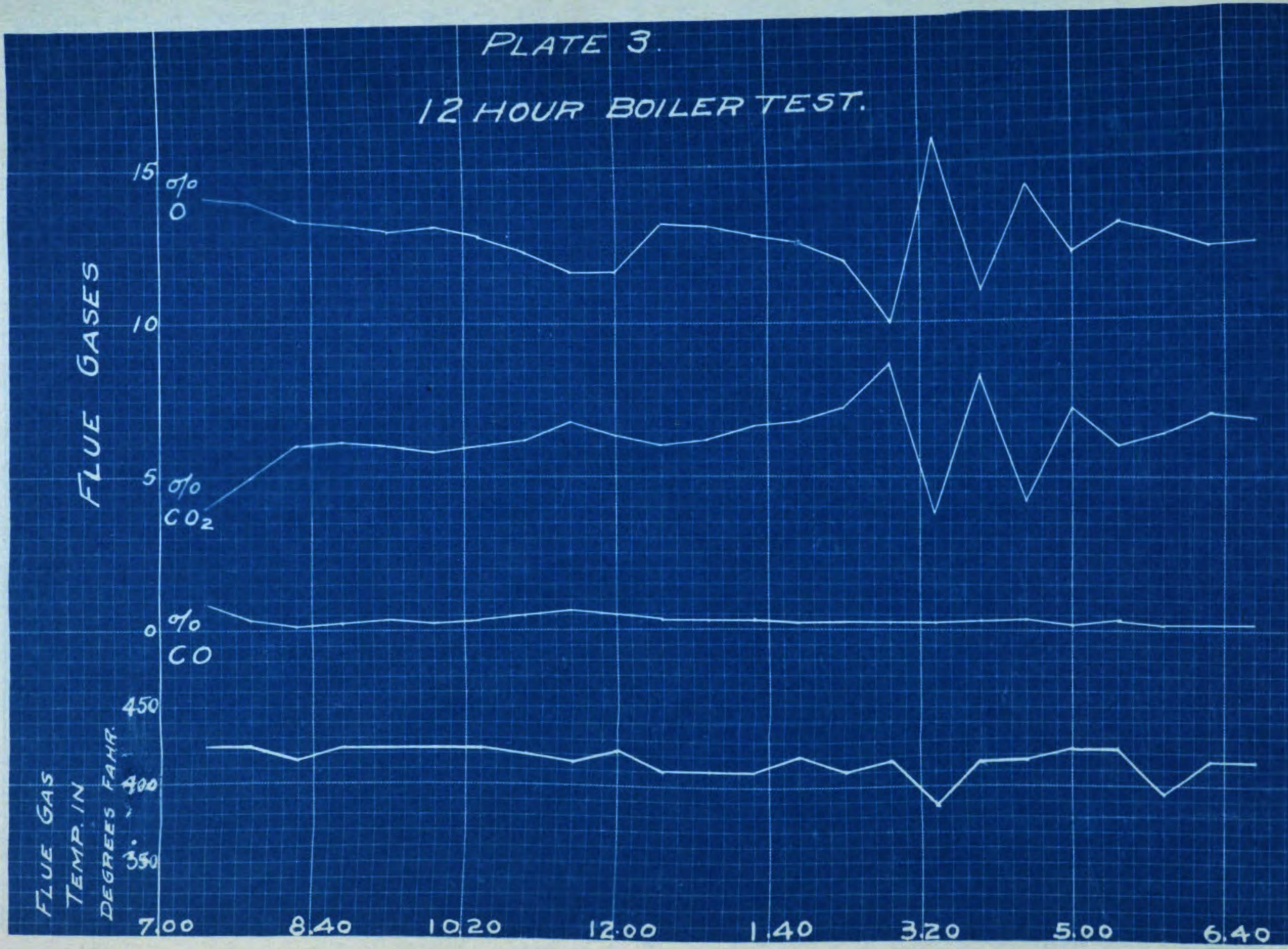

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Tests of Terry Turbine Direct-Connected to Northern Generator.

Object.

The object of the first test on the exciter unit was to determine if the performance of the unit fulfilled the guarantee of the manufacturer. Having determined from the results of the first test that the performance was unsatisfactory, we sought in the three following tests to determine the operation with slight changes in the governor, with change of nozzles and lastly, we sought to analyze the existing conditions in various parts of the turbine in operation.

Method of Making the Tests.

The generator load consisted of a water rheostat, and a man was stationed to keep the load as constant as possible. The steam pressure and quality were taken at the turbine throttle. A mercury manometer was connected to the turbine exhaust pipe in order to obtain exhaust back pressure readings. Data for the quality of steam was obtained by the use of a throttling calorimeter. All exhaust steam from the turbine was condensed in a Wheeler surface condenser and weighed. The first test was made on the turbine just as it was sent from the manufacturer. The second test

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was made with a set of larger nozzles in the turbine. In the third test the condensed steam was not weighed and the run consisted mainly of a test on the speed control of the turbine governor. Our last and fourth test on the unit was made similar to test Number I. In addition to obtaining the same data as in test Number I, a steam pressure gauge was placed between the governor and nozzles. This gauge gave the steam pressure at the nozzle. Speeds were obtained by use of a speed counter, and a tachometer accurate within about 5/10 of 1%.

Instruments Used.

De Laval Steam Gauge used for nozzle pressure in test #4.

Bourdon Steam Gauge used for steam pressure at governor in all tests.

Weston D. C. Voltmeter No. 16808; 0 to 150.

Weston D. C. Ammeter No. 6010; 0 to 25.

Weston D. C. Ammeter No. 7161; 0 to 500.

Results of Tests.

Test No. I performed March 6th and 7th, 1909.

Above a 306 ampere load, the turbine speed falls off very rapidly resulting in a low generated voltage. It was impossible under these conditions to get the rated full load on the turbine.

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It should be mentioned that at the 306 ampere load and above, the governor was wide open.

Test No. 2 performed March 23rd, 1909.

This test gives about the same results as test No.I. The terminal voltage of the generator is up nearly to normal,although the turbine speed is down to nearly 2400 R. P. M. when it should be 2500. It will be noticed that the exciting current in test No. 2 is higher than it is in test No. I.

Test No. 3 performed March 30th, 1909.

It was found that if the load on the generator was pushed beyond 375 amperes, the speed of the turbine dropped sufficiently to make it impossible to maintain normal voltage with the field rheostat entirely cut out.

The current was run up to 490 amperes and it was found that the voltage dropped to 90 volts and the speed to 2090 revolutions per minute. The load was suddenly thrown off at this point and the speed ran to 2640 R. P. M. fluctuated for seventeen seconds and then fell back to 2560 R. P. M. and remained there.

Test No. 4 performed April 7th, 1909.

Above 400 amperes load on the generator, the speed of the turbine commenced to decrease very rapidly

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and at 440 amperes the speed was 2260 R. P. M., while the generated voltage was only 112 volts with all of the field resistance cut out. When the load was thrown off, the speed of the turbine ran up to 2700 R. P. M.

Conclusion.

In the conclusion of the discussion of the test on the Terry turbine and Northern generator exciter unit, it may be said that, (1) the speed control of the governor is poor; (2) the steam consumption per B. H. P. output is too large; (3) the turbine is unable to operate satisfactorily with full load on the generator, because the speed is down too low; (4) the turbine is able to carry a larger load with the larger sized nozzles, but the steam consumption per B. H. P. of the turbine is also increased as the size of nozzle is increased, as shown by the curves.

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TEST ON TERRY TURBINE DIRECT-CONNECTED TO NORTHERN GENERATOR.
March 6, 1909.

Load Amps. = 0; Gen. Term. volts = 124.8; Exciting Amps. = 2.8

Time	Gauge press. in lbs/sq. inch	R.P.M.	Lbs. of condensed steam	Temp. of condensed steam	Exhaust back press in inches of Hg.	Calorimeter Temp.	Calbrimeter back press. in inches of Hg.
5:10-5:15	147.5	2536	59.0	68 °F	0.10		
5:15-5:20	151.5	2545	59.5	71	0.10	267 °F	4.55
5:20-5:25	150.0	2531	59.0	67	0.10		
5:25-5:30	155.0	2530	59.0	66	0.11		
5:30-5:35	147.0	2533	60.0	65	0.10		
5:35-5:40	148.0	2532	59.5	65	0.10		
5:40-5:45	152.0	2535	59.5	65	0.13		
5:45-5:50	144.5	2527	59.5	65	0.10	273	6.8
5:50-5:55	152.0	2530	59.5	65	0.15		
5:55-6:00	147.0	2535	61.0	65	0.15		
6:00-6:05	148.0	2525	60.0	65	0.15		
6:05-6:10	139.5	2521	60.5	65	0.15	274	6.7

Load Amps. = 73.6; Gen. Term. volts = 121.0; Exciting Amps. = 2.8

Time	Gauge press. in lbs/sq. inch	R.P.M.	Lbs. of condensed steam	Temp. of condensed steam	Exhaust back press in inches of Hg.	Calorimeter Temp.	Calbrimeter back press. in inches of Hg.
6:20-6:25	151	2531	105.5	89 °F	0.15		
6:25-6:30	152	2520	106.5	89	0.15		
6:30-6:35	148	2520	106.0	89	0.15		
6:35-6:40	152.5	2520	106.0	92	0.15		
6:40-6:45	151.5	2490	105.0	90	0.15	278 °F	6.8
6:45-6:50	150	2543	116.0	93	0.15		
6:50-6:55	150	2500	119.5	97	0.15		

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6:55-7:00	152.5	2470	118.0	97	0.16		
7:00-7:05	152	2470	115.0	96	0.17		
7:05-7:10	151	2467	117.0	96	0.20		
7:10-7:15	150	2479	119.5	96	0.15		
7:15-7:20	152	2509	120.0	96	0.15	276 °F	7.1

Load Amps. = 157.1; Gen. Term. volts = 124.8; Exciting Amps. = 2.8

7:35-7:40	152.0	2495	162	117	0.25		
7:40-7:45	149.5	2494	164	118	0.25		
7:45-7:50	150.0	2493	163	118	0.25		
7:50-7:55	148.5	2484	164	116	0.27		
7:55-8:00	150.0	2479	164	116	0.25	278	7.2
8:00-8:05	151.0	2490	164	116	0.25		
8:05-8:10	150.0	2486	163.5	116	0.30		
8:10-8:15	149.0	2495	163	116	0.30		
8:15-8:20	149.0	2490	162	116	0.30		
8:20-8:25	152.0	2487	152.5	116	0.30	280	7.1
8:25-8:30	151.5	2496	164	116	0.30		
8:30-8:35	149.0	2500	162	116	0.30		

Load Amps. = 243.9; Gen. Term. volts = 124.8; Exciting Amps. = 2.72

8:45-8:50	150	2520	206.5	104	0.35		
8:50-8:55	151	2485	205	104	0.45	279	6.6
8:55-9:00	151	2496	207	104.5	0.45		
9:00-9:05	150	2492	205.5	104	0.40		
9:05-9:10	150	2496	206	104.5	0.42		
9:10-9:15	149	2487	205	105	0.39		
9:15-9:20	150	2490	205.5	105.3	0.41		
9:20-9:25	150	2491	204.5	105	0.42		

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9:25-9:30	151	2495	205	105	0.41		
9:30-9:35	148	2482	205	105.5	0.41		
9:35-9:40	149	2500	207.5	105.5	0.42		
9:40-9:45	150	2495	208	105	0.42		

Load Amps. = 285.2; Gen. Term. volts = 124.8; Exciting Amps. = 2.7

P. M.							
10:05-10:10	146.5	2505	224.0	109.5	0.35		
10:10-10:15	150.0	2508	224.5	109.5	0.35		
10:15-10:20	150.5	2498	225.5	109.7	0.35	278	6.7
10:20-10:25	149.5	2494	223.5	110.0	0.35		
10:25-10:30	150.0	2497	225.5	110.0	0.35		
10:30-10:35	149.0	2497	225.0	110.0	0.40		

Load Amps. = 306.0; Gen Term. volts = 124.8; Exciting Amps. = 2.7

10:45-10:50	151	2496	233.5	112	0.40		
10:50-10:55	147.5	2497	235	111.3	0.40		
10:55-11:00	150	2497	235	112	0.40	281	7.0
11:00-11:05	151	2502	233	112.5	0.41		
11:05-11:10	150	2498	234	112.5	0.40		

Load Amps. = 326.8; Gen. Term. volts = 117.5; Exciting Amps. = 2.8

March 7, 1909.

A. M.							
10:05-10:10	147	2155	241	116	0.40		
10:10-10:15	149	2192	244	117	0.40	280	6.4
10:15-10:20	148	2200	245	117	0.44		
10:20-10:25	147	2245	245.5	118	0.44		
10:25-10:30	150	2241	241	116.5	0.44	280	6.4
10:30-10:35	150	2262	243	117.	0.44		

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RESULTS OF TEST ON TERRY TURBINE DIRECT-CONNECTED TO NORTHERN GENERATOR PERFORMED ON MARCH 6 AND 7, 1909.

	1	2	3	4	5	6	7
							Mar. 7-09
Time of run	5:10 6:10	6:20 7:20	7:35 8:35	8:45 9:45	10:05 10:35	10:45 11:10	10:05 10:35
Duration of run in min.	60	60	60	60	30	25	30
Amperes load	0	73.6	157.1	243.9	285.2	306	326.8
Terminal volts	124.8	121	124.8	124.8	124.8	124.8	117.5
Load output - K. W.	0	8.925	19.6	30.4	35.6	38.2	38.5
% Rated full load output	0	22.4	49.1	76.0	89.0	95.5	96.3
Efficiency of Gen. -%	0	73.0	84.0	88.0	88.9	89.0	89.4
B. H. P. of turbine	0	16.4	31.25	46.25	53.7	57.5	57.8
Av. turbine speed R.P.M.	2532	2502	2491	2494	2500	2498	2216
Exhaust back press. in inches of Hg above at.	0.12"	0.156"	0.28"	0.412"	0.36"	0.40"	0.43"
Gauge press #/in^2	148.5	151.04	150.12	149.9	149.25	149.9	148.5
Inches Hg Cal. back press	6.01"	6.95"	7.15"	6.5"	6.7"	7.0"	6.4"
Atmos. press. in inches Hg	28.9"	28.9"	28.9"	28.9"	28.9"	28.9"	29.0"
Temp. in calorimeter	271 °F	277 °F	279 °F	281.5 °F	278 °F	281 °F	280 °F
Quality of steam in % Dry	97.7	98.0	98.1	98.4	98.1	98.3	98.3
Total steam/hr. wet lbs.	716	1354	1953	2470	2696	2809	2909
Total steam/hr. dry lbs.	699.5	1326.9	1915.8	2430.9	2644.9	2761.0	2859.5
Lbs. steam/KW hr. output Wet	-	151.9	99.7	81.2	75.6	73.5	75.5
Lbs. steam, KW hr. output Dry	-	148.5	97.8	80.0	74.4	72.4	74.1
Lbs. steam/B.H.P. output Wet	-	82.6	62.45	53.45	50.2	48.75	50.2
Lbs. steam/B.H.P. output Dry	-	80.9	61.2	52.6	49.3	48.05	49.3
% Heat transformed into B.H.P.	-	3.69	4.86	5.65	6.05	6.19	6.05
% Heat transformed into Electrical energy	-	2.69	4.08	4.96	5.39	5.50	5.39

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SECOND TEST ON TERRY TURBINE DIRECT-CONNECTED TO NORTHERN GENERATOR.
MARCH 23, 1909.

Load Amps. = 167.7; Gen. Term. volts = 124.45; Exciting Amps. = 3.1

Time	Gauge press # 2. /in	R.P.M.	Lbs. of condensed steam	Temp. of condensed steam	Exhaust back press in inches of Hg.	Calorimeter Temp.	Calorimeter back press in inches of Hg.
3:45-3:50	147	2403	254.5	120 °F	0.50	284 °F	7.6"
3:50-3:55	151	2405	251.0	120	0.48		
3:55-4:00	148	2409	254.5	121	0.51		
4:00-4:05	148	2408	251.5	121	0.47	285 °F	7.6"
4:05-4:10	148	2408	256.8	121	0.46		
4:10-4:15	150	2409	253.0	121	0.45		

Load Amps. = 322.46;:Gen. Term. volts = 124.80; Exciting Amps. = 2.91

4:25-4:30	150	2413	172.5	104.5	0.44		
4:30-4:35	151	2428	174.5	104	0.45	284	7.65
4:35-4:40	151	2403	174.6	104.5	0.43		
4:40-4:45	154	2403	176.0	104	0.43		
4:45-4:50	155	2424	174.5	104	0.41		
4:50-4:55	153	2414	173.0	104	0.41		

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RESULTS OF TEST ON TERRY TURBINE DIRECT-CONNECTED TO NORTHERN GENERATOR PERFORMED ON MARCH 23, 1909.

	A	B
Time of run	3:45-4:15	4:25-4:55
Duration of run in min.	30	30
Amperes load	161.7	322.46
Terminal volts	124.45	124.80
Load output - K. W.	20.12	40.24
% Rated full load output	50.3	100.6
Efficiency of Gen. %	84.5	89.5
B. H. P. of turbine	22.92	48.4
Average R. P. M. of unit	2414	2407
Exhaust back pressure in inches of Hg above At.	.43"	.48"
Gauge press #/in^2	148.60	152.30
Inches Hg back press Cal.	7.6	7.65
Atmospheric press. in inches Hg	28.95	28.95
Temp. in calorimeter	284.5	284.0
Quality of steam % dry	98.5	98.6
Total steam/hr. -wet - lbs.	2090.4	3043.2
Total steam/hr. -dry - lbs.	2059	3000
Lbs. steam/K.W. hr. output-wet	103.8	75.6
Lbs. steam/K.W. hr. output-dry	102.0	74.5
Lbs. steam/B.H.P. turbine output wet	91.0	62.9
Lbs. steam/B.H.P. turbine output dry	90.0	62.0
% Heat transformed into B.H.P. at turbine	3.3	4.8
% Heat transformed into Electrical Energy	2.79	4.3

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RESULTS OF TEST ON TERRY TURBINE DIRECT-CONNECTED TO NORTHERN GENERATOR FOR DETERMINING THE SPEED REGULATION OF THE TURBINE.
MARCH 30, 1909.

Volt meter readings	Am-meter readings	K. W. output	% Eff. of Gen.	B.H.P. output of turbine	R.P.M. of turbine	Gauge press #/in²	Back press. of exhaust in inches of Hg
125.24	0	0			2620	151	1.2
125.24	49.9	6.25			2600	152.5	1.2
125.24	100.0	12.52	78.0	21.53	2600	149	1.2
125.24	152.0	19.05	83.5	30.6	2460	151	1.2
125.24	203.5	25.47	86.7	39.4	2430	151.5	1.25
125.24	280.0	31.34	88.4	47.5	2430	148	1.25
125.24	276.0	34.6	89.0	52.2	2440	148	1.3
125.24	299.8	37.55	89.3	56.4	2440	147.5	1.3
125.24	319.5	39.95	89.5	59.25	2440	145	1.3
125.24	349.6	43.76	89.8	65.3	2400	143	1.3
125.24	375.0	47.00	89.9	70.2	2410	150	1.3
121.24	398.0	48.25	90.0*		2320	147	1.3
101.9	440.2	44.3	90.0*		2190	146	1.35
89.0	493.6	44.3	89.6*		2090	146	1.35

* These efficiencies can hardly be taken as the voltage of the generator is not up to normal.

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RESULTS OF TEST #3 PERFORMED ON EXCITER UNIT
MARCH 30, 1909.

%Full load on turbine	%Rated speed
28.7	104
40.8	98.5
52.5	97.3
63.3	97.3
69.5	97.6
75.2	97.6
79.0	97.6
87.0	96.0
93.6	96.5

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DATA ON FOURTH TEST OF EXCITER UNIT
APRIL 7, 1909.

Load Current = 110.4; Gen. Term. volts = 125.1

Time	Gauge press at Turb lbs/sq. inch	Gauge press on nozzles lbs/sq. inch	R.P.M.	Lbs. of condensed steam	Exhaust back press in inches of Hg.	Calorimeter Temp.	Calorimeter back press in inches of Hg.
PM							
8:30	150	63	2620	154	1.4		
8:35	150	62.5	2610	157	1.45	271 °F	6.6
8:40	147	62	2610	154	1.4		
8:45	145	62	2600	153	1.4		
8:50	150	62	2610	154	1.0	271	6.6
8:55	150	62	2620	154	1.0		

Load Current = 162.3; Gen. Term. volts = 125.1

Time	Gauge press at Turb lbs/sq. inch	Gauge press on nozzles lbs/sq. inch	R.P.M.	Lbs. of condensed steam	Exhaust back press in inches of Hg.	Calorimeter Temp.	Calorimeter back press in inches of Hg.
PM							
9:05	146	75	2600	175	0.60		
9:10	150	73	2590	177	0.50	272 °F	6.8
9:15	147	76	2600	175	0.50		
9:20	150	73	2620	175	0.45		
9:25	150	74	2630	175	0.65	273	6.6
9:30	147	76	2590	175	0.50		

Load Current = 243.9; Gen. Term. volts = 125.1

Time	Gauge press at Turb lbs/sq. inch	Gauge press on nozzles lbs/sq. inch	R.P.M.	Lbs. of condensed steam	Exhaust back press in inches of Hg.	Calorimeter Temp.	Calorimeter back press in inches of Hg.
PM							
9:40	143	96	2600	212	0.5		
9:45	147	95	2600	211	0.45	270 °F	6.1
9:50	152	97	2610	210	0.45		
9:55	147	93	2600	212.5	0.4		
10:00	146	96	2610	209	0.4	272	6.0
10:05	145	94	2600	210.5	0.4		

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DATA ON FOURTH TEST OF EXCITER UNIT - Continued
APRIL 7, 1909.

Load Current = 325.8; Gen. Term. volts = 125.1

PM							
10:15	143	118	2600	252	0.45		
10:20	147	120	2610	247	0.45	269° F	6.3
10:25	150	120	2600	252.5	0.5		
10:30	150	120	2610	243	0.58	272	6.1
10:35	150	120	2620	243	0.6		
10:40	150	118	2600	251	0.6		

Load Current = 398 Amps.; Gen. Term. volts = 125.1

PM							
10:50	150	141	2370	285	1.00		
10:55	150	140	2500	286	0.95	269° F	6.3"
11:00	152	137	2600	276	0.95		
11:05	151	140	2540	278	1.05		
11:10	152	140	2570	281	1.00	271° F	6.3"
11:15	150	136	2550	281	0.85		

Load Current = 440 Amps.; Gen. Term. volts = 112.

PM							
	148	145	2600		.8		
	145	142	2600		.85		
	144	141	2600		.95		
	144	141	2580		1.2		
	144	141	2180		1.4		

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RESULTS OF FOURTH TEST ON EXCITER UNIT
PERFORMED APRIL 7, 1909.

	A	B	C	D	E	F
Duration of each Test 1/2 hour						
% Turbines rated full load	31.2	43	61.5	81.8	99.2	
% Generator's rated full load	34.5	50.7	76.3	100.2	124.5	
Generated voltage	125.1	125.1	125.1	125.1	125.1	112
Load in Amperes	110.4	162.3	243.9	326.8	398	440
Load in K. W.	13.81	20.30	30.50	40.88	49.79	48.84
Steam press. at Turbine ahead of governor	148	145	142	145	145	145
Steam press. on nozzles	62	73	93	120	140	142
Exhaust press. in inches of Hg	.8	.85	.90	1.2	1.4	
R. P. M. of Turbine	2610	2607	2600	2600	2552	2260
% Dryness of steam	98	98		98	9 8	
Lbs. of dry steam required/hr.	1815	2062	2479	2916.5	3306.5	
Lbs. of steam condensed/hr.	1852	2104	2530	2976	3374	
Lbs. of dry steam/K.W.H. output	131.4	101.5	81.4	71.3	66.4	
% Eff. of Generator (taken from Mfg. Eff. Curves)	79	84.6	88.3	89.5	90.0	
Brake H. P. developed by Turbine	**23.4**	**32.2**	**46.2**	**61.4**	**74.3**	
Lbs. dry steam/ B. H. P.	**77.6**	**64.3**	**53.5**	**47.5**	**44.5**	

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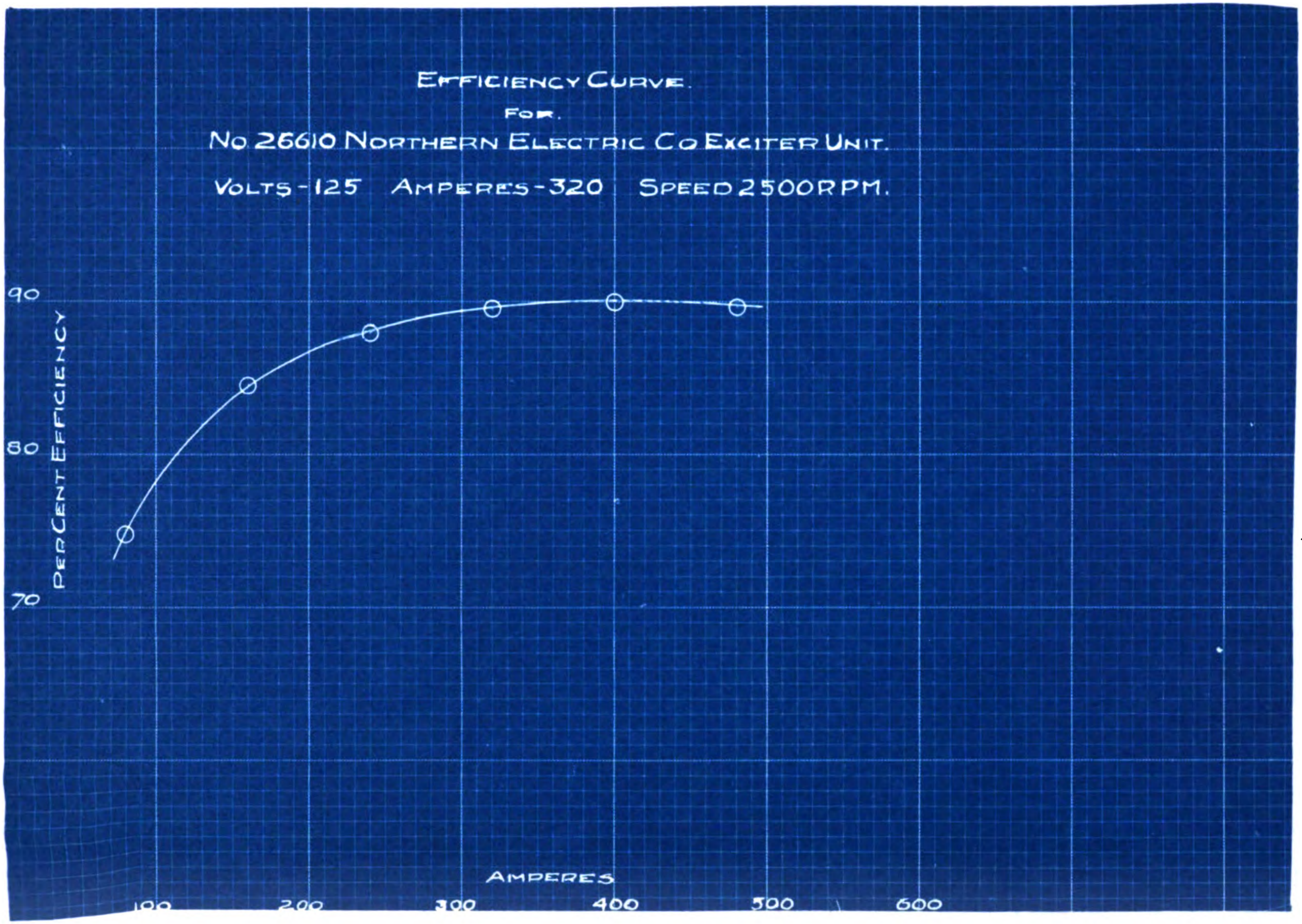

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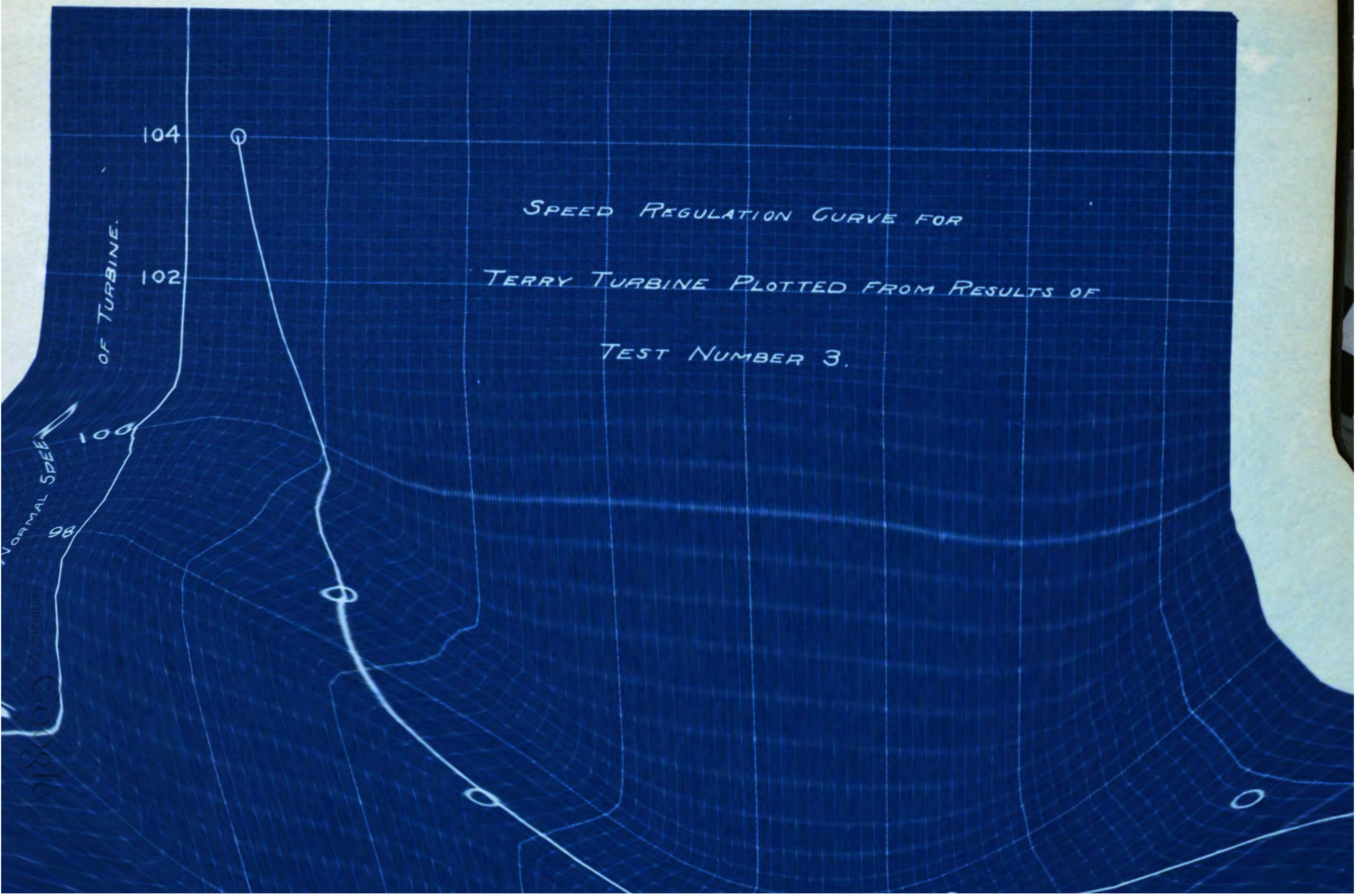

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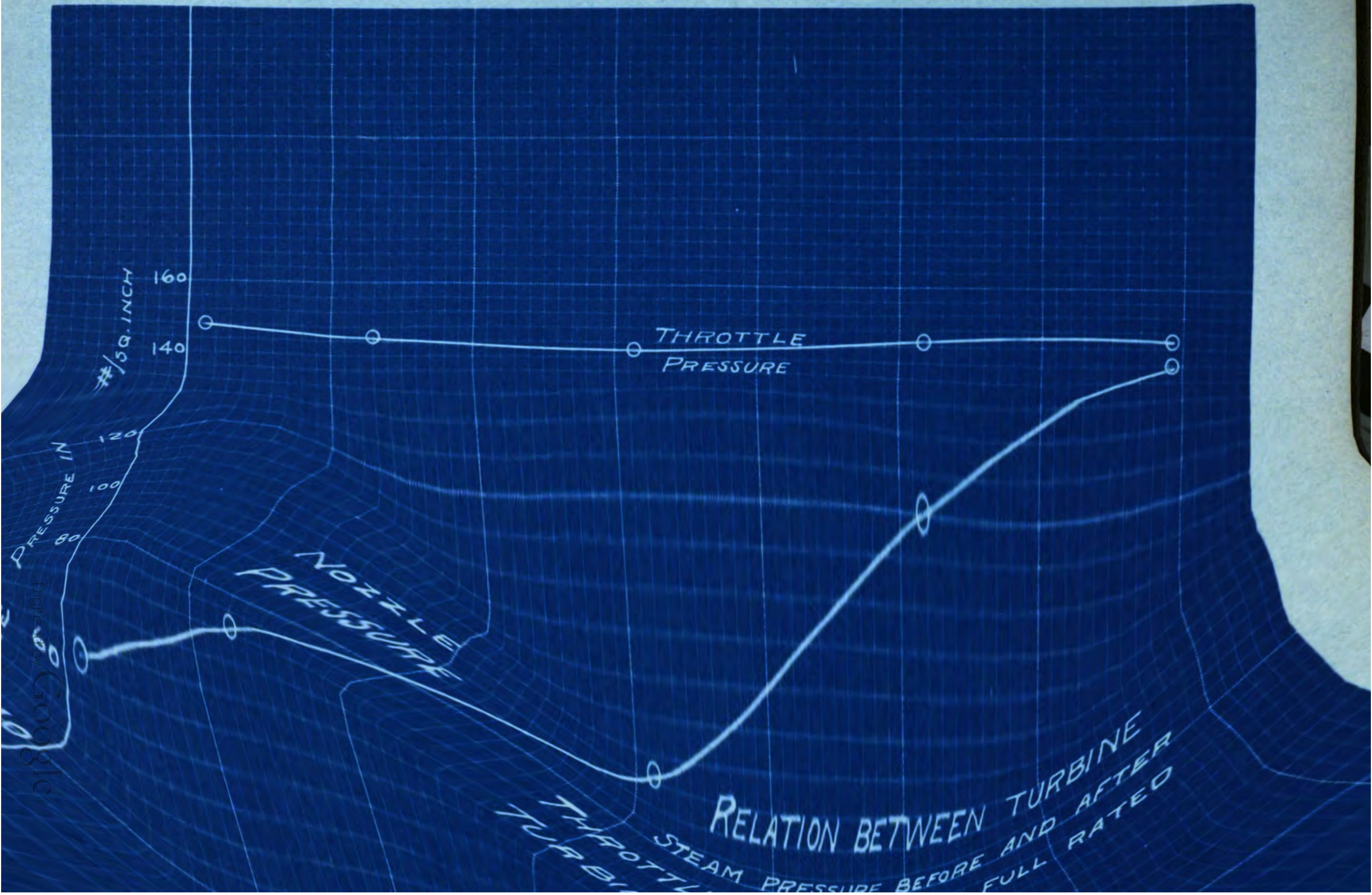
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PRESSURE IN
THROTTLE PRESSURE
NOZZLE PRESSURE
RELATION BETWEEN TURBINE
STEAM PRESSURE BEFORE AND AFTER
FULL RATED

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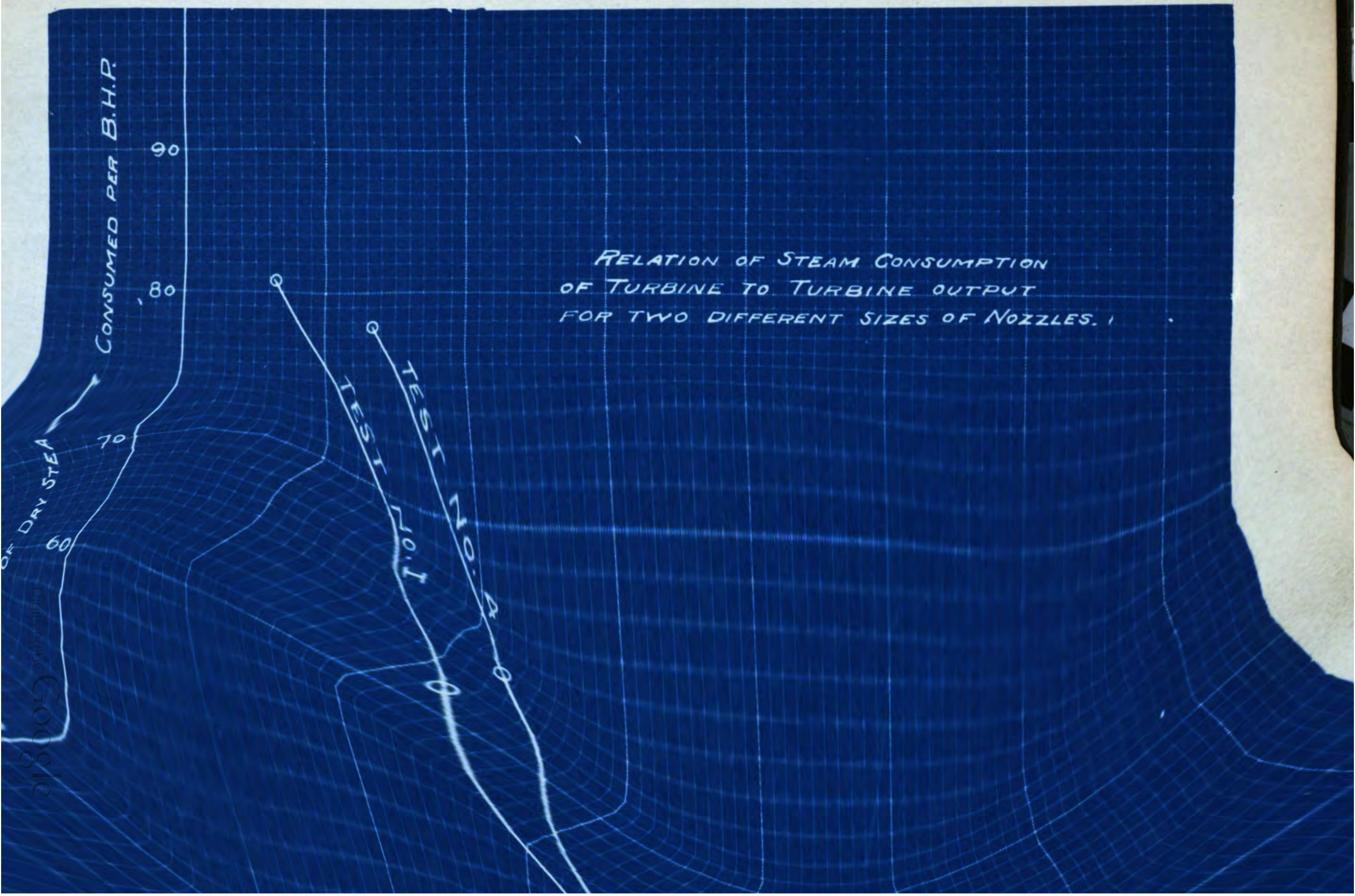

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FRONT OF BOILER.

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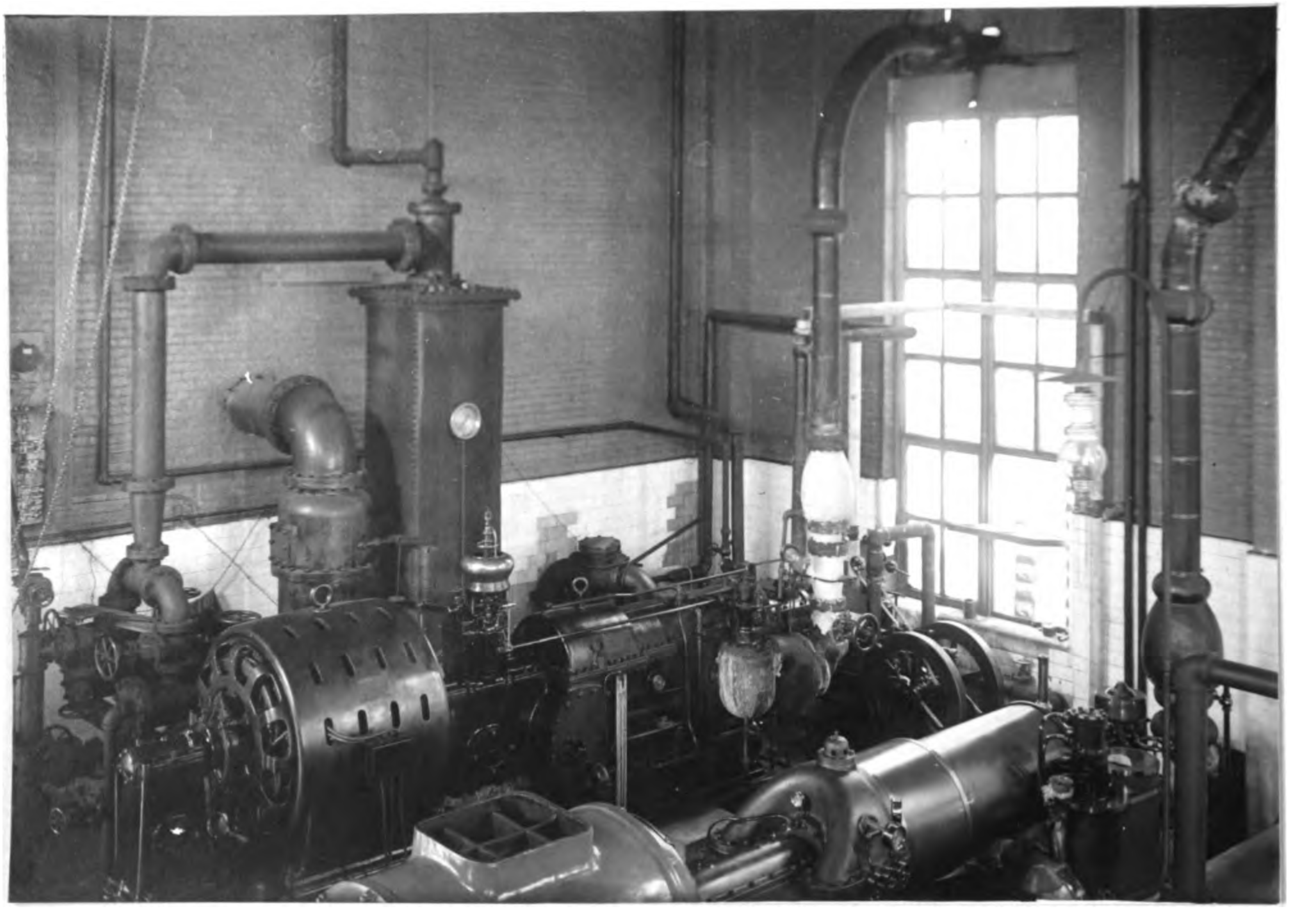

400 K.W. TURBO-GENERATOR.

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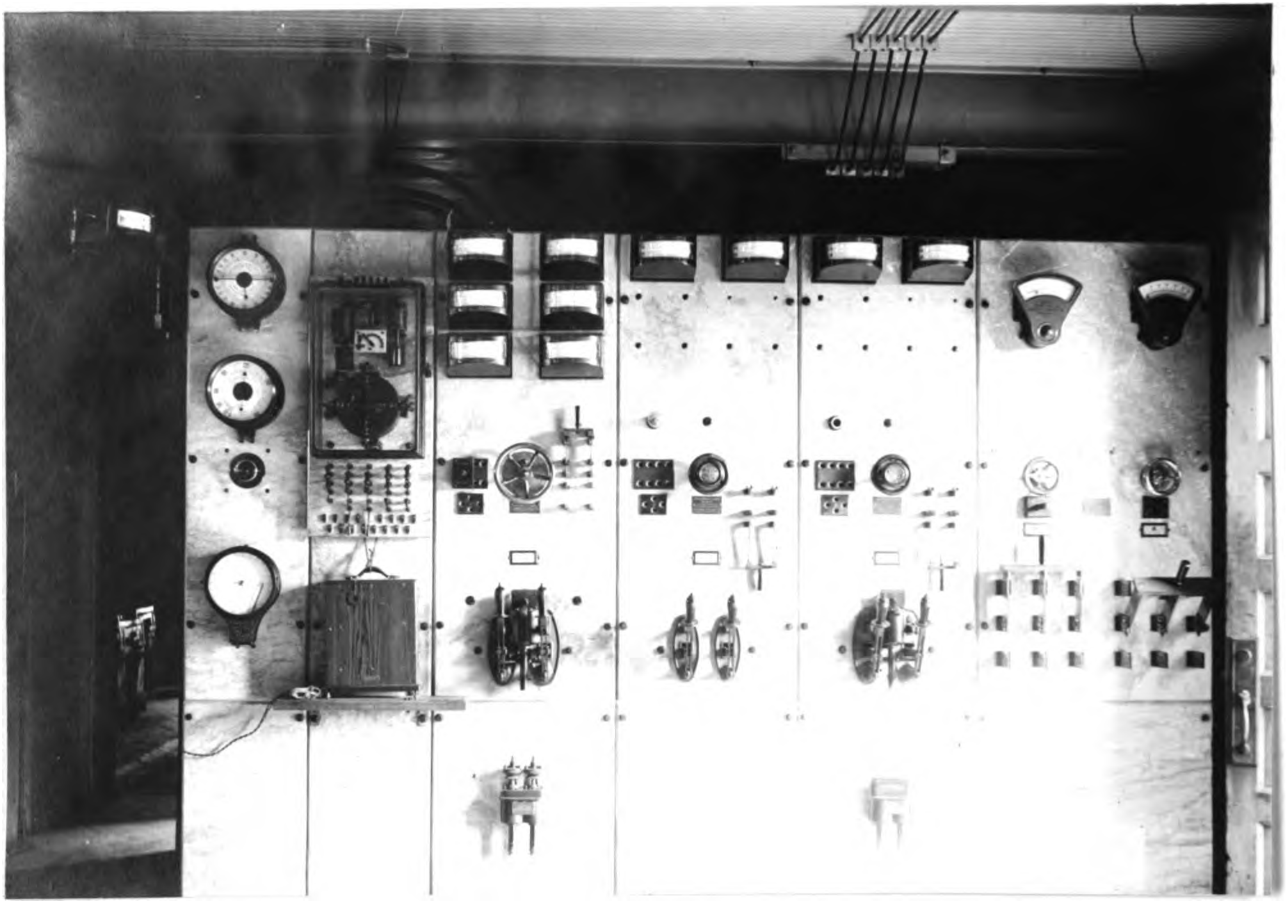

SWITCH BOARD

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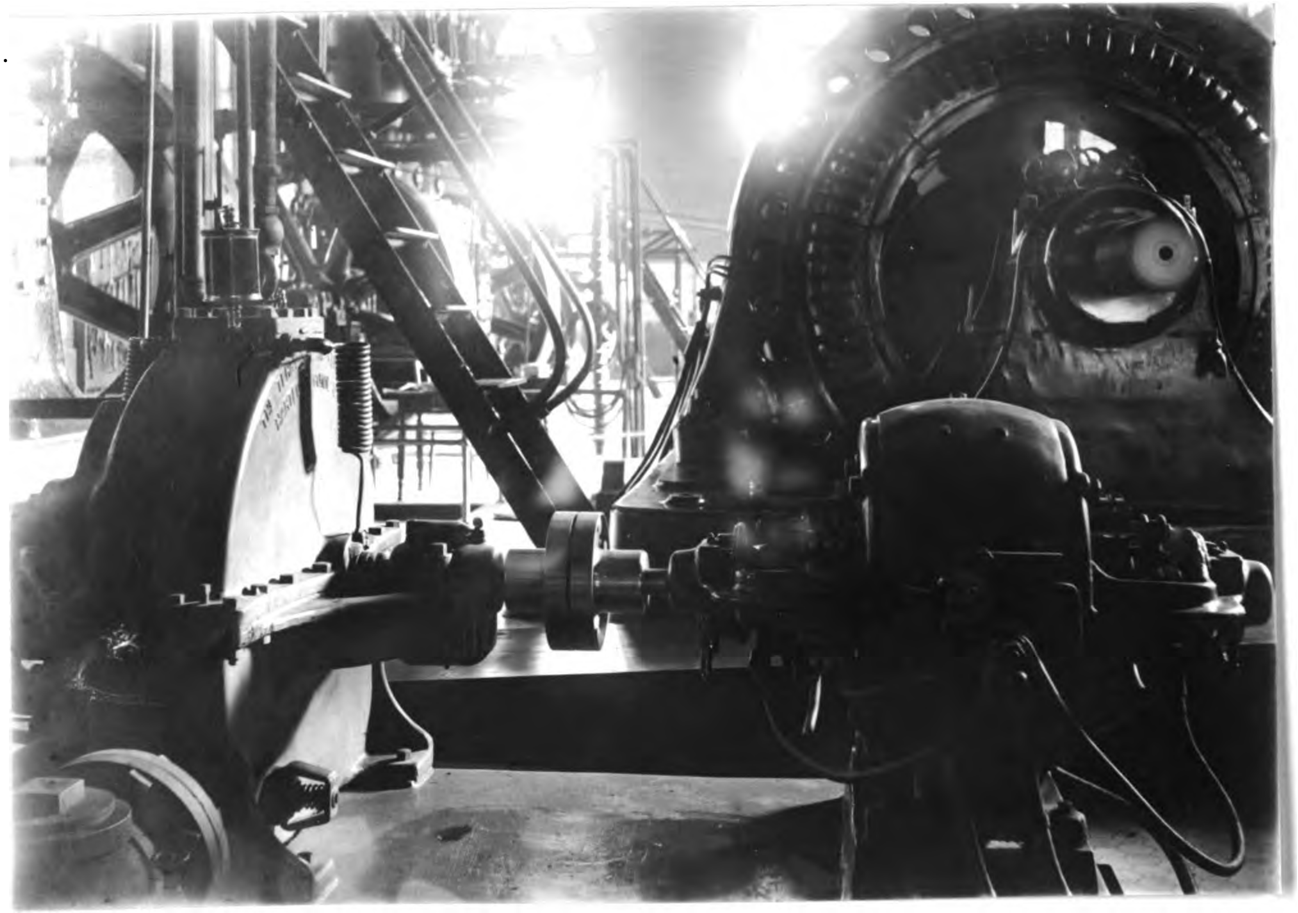

EXCITER UNIT.

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Calibrations

Steam Pressure Gauges.

The steam pressure gauges used on any of the tests were calibrated by means of a Crosby Gauge Tester at increments of 5 pounds per square inch for both increasing and decreasing pressures over the entire scale of the pressure gauge and the average of these two curves was taken as the final calibration curve.

Ammeters.

The direct current ammeters were calibrated against standards for both increasing and decreasing values of current and the average of these two curves was taken as the final calibration curve.

The alternating current ammeters were calibrated against the same standards with direct current for increasing and decreasing values of current with the current flowing first in one direction and then with the current reversed and the average of the four curves was taken as the final calibration curve.

Voltmeters.

The direct current voltmeters were calibrated against standards for both increasing and decreasing values of voltage and the average of these two curves was taken as

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the final calibration curve.

The alternating current voltmeters were calibrated against the same standards with direct current for increasing and decreasing values of voltage with the voltage first in one direction and then with the voltage reversed and the average of the four curves was taken as the final calibration curves.

Indicating Wattmeters.

The indicating wattmeters were calibrated with direct current and compared with the readings of a standard ammeter and standard voltmeter. Readings were taken for both increasing and decreasing watts and the average of the two curves was taken for the final calibration curve.

Thermo-Couples.

The thermo-couples were calibrated in an electric furnace by comparison with a standard thermo-couple. The milli-voltmeter used in connection with the thermo-couple was not calibrated separately.

Thermometers.

The thermometers used were calibrated in an oil bath against two standard centigrade thermometers and the thermometers were immersed in the oil bath to sufficient

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depth to completely submerge the mercury column. All thermometers checked at the melting point, (as determined by submerging the thermometers in melting snow) and at the boiling point when immersed in the oil bath. At the highest temperature reading, 280 ^{o}F, the greatest variation of any of the thermometer readings from the standard was about 2 degrees F, as near as could be read. For our purposes all of the calibrated thermometers were assumed to read correct.

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Calibration of Series Current.

Transformers.

Transformers Calibrated.

1. Westinghouse Series Transformer No. 49182 with current coil of Weston Wattmeter No. 267 (0 to 1500) and Westinghouse A. C. Ammeter No. 104502 in the secondary of the transformer.

2. Westinghouse Series Transformer No. 49203 with current coil of Weston Wattmeter 2850 (0 to 1500) and Weston A. C. Ammeter No. 291, (0 to 5) connected in series in the secondary of the transformer.

All these instruments had been previously calibrated. Each transformer was connected with its secondary to the instruments grouped with it. These instruments were the same as those used for measuring the power in the test on the Turbo Generator.

The primary of the transformer consisted of passing the cable lead from the source of power twice through the opening in the transformer.

At first an attempt was made to measure the current in the primary by means of a Kelvin Balance using it as an Ammeter. This calibration, however, gave a curve showing the relation between secondary amperes and ratio $\frac{\text{Primary Amps.}}{\text{Secondary Amps.}}$ which sloped the wrong way. It was found

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after calibrating the transformers twice that this error was due to a change in P. F. as the current increased. Therefore, the results obtained from these calibrations were discarded and the series transformers were calibrated by means of a Comparator.

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Calibration of Series Transformers.

The comparator was used to measure the primary current. A Thomson A. C. 0 to 200 Ammeter was connected in series with the comparator shunt in order to obtain the approximate primary current.

The comparator consists of two paralell wires, each having the same material, the same resistance and the same temperature coefficient and the same specific heat. A mirror is connected rigidly to these two wires and a zero adjustment obtained on a scale.

It stands to reason that when the same effective value of current flows through each wire, each will lengthen exactly the same amount and the mirror read through a telescope will read the same as the zero reading.

The current is measured by comparing a definite fractional part of the total primary current with an equal value of direct current and measuring the value of direct current very accurately by means of a potentiometer. This fractional part of the total primary current is obtained by shunting one of the wires across the shunt of the comparator. The other wire is used for the equal direct current.

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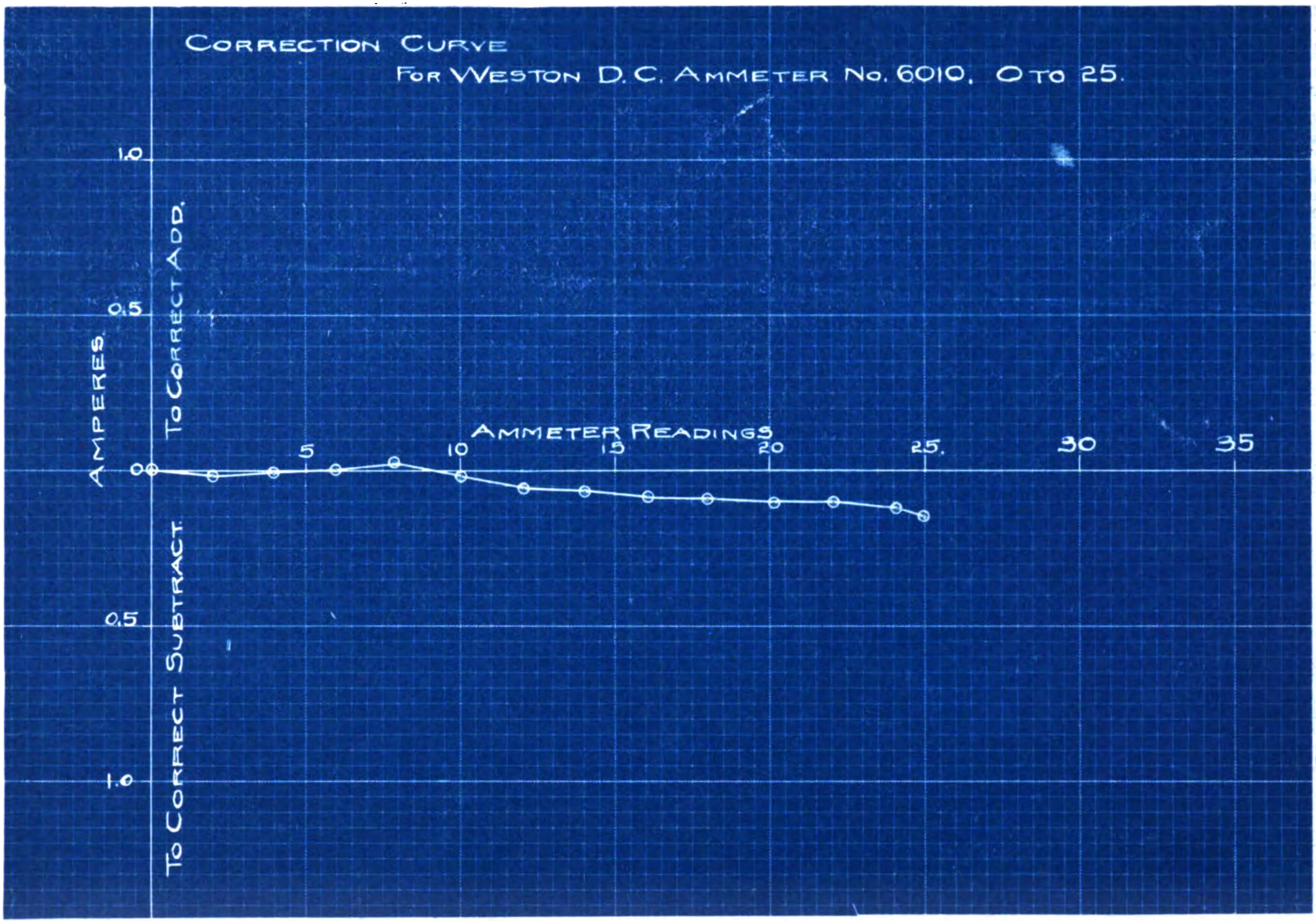

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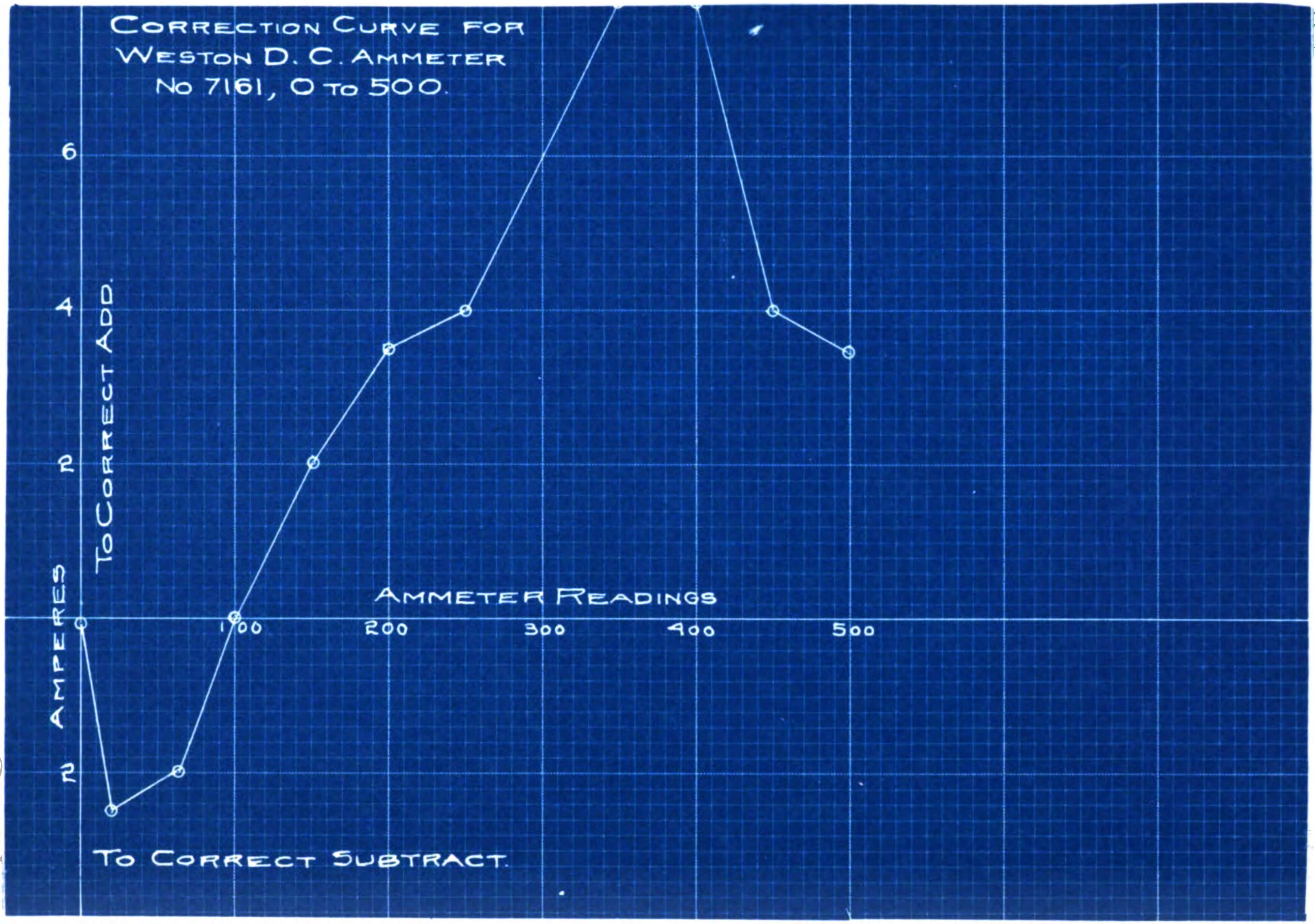

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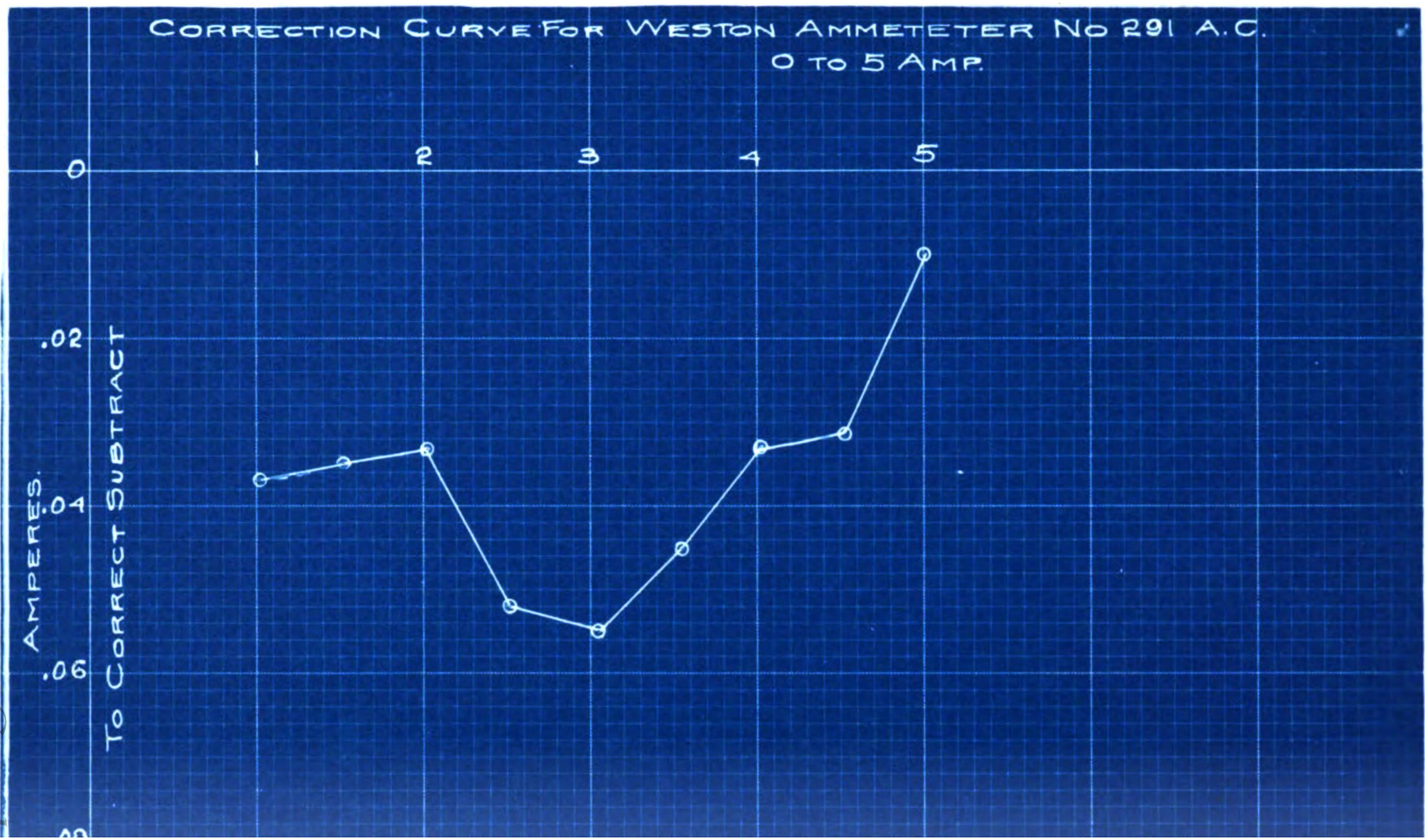

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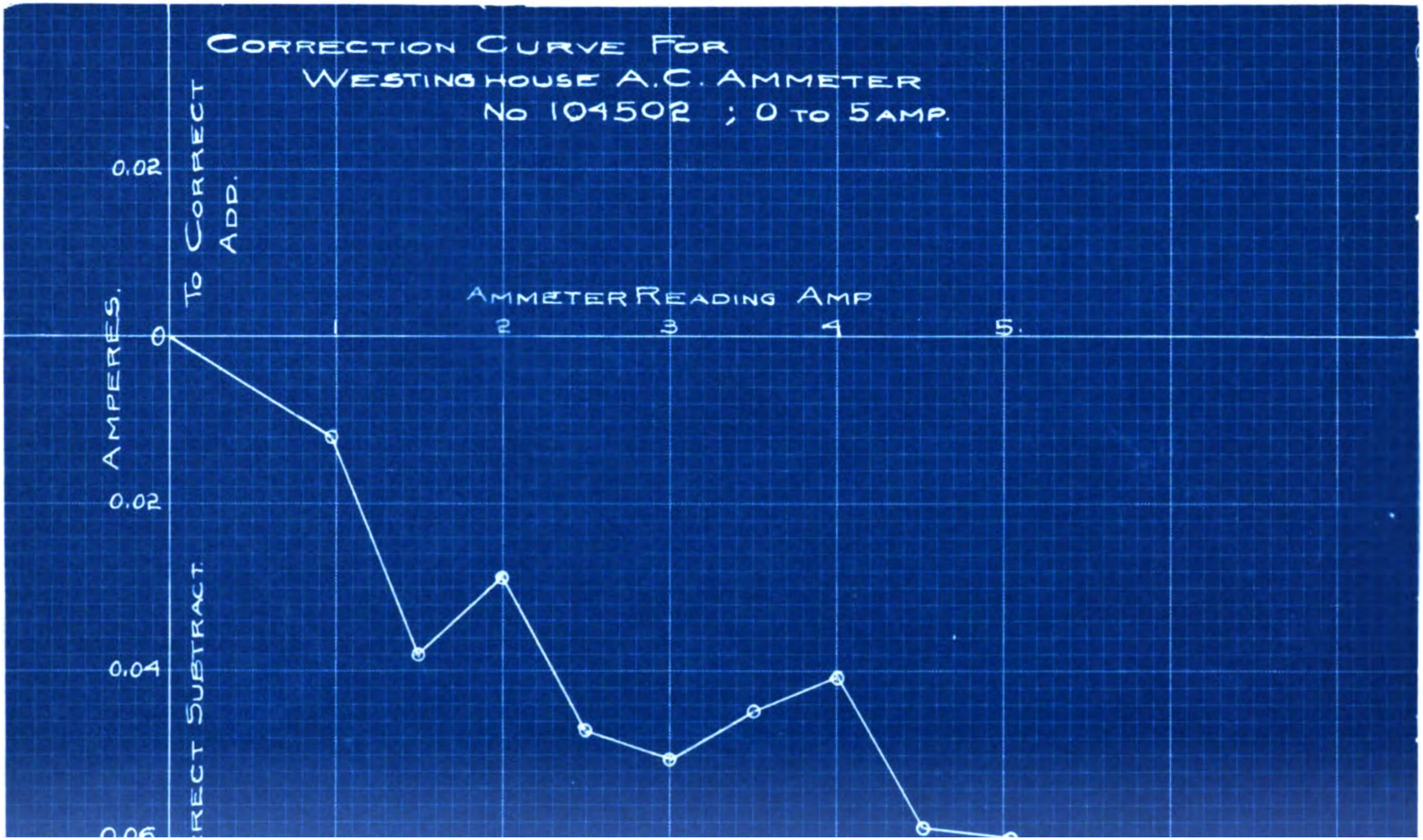

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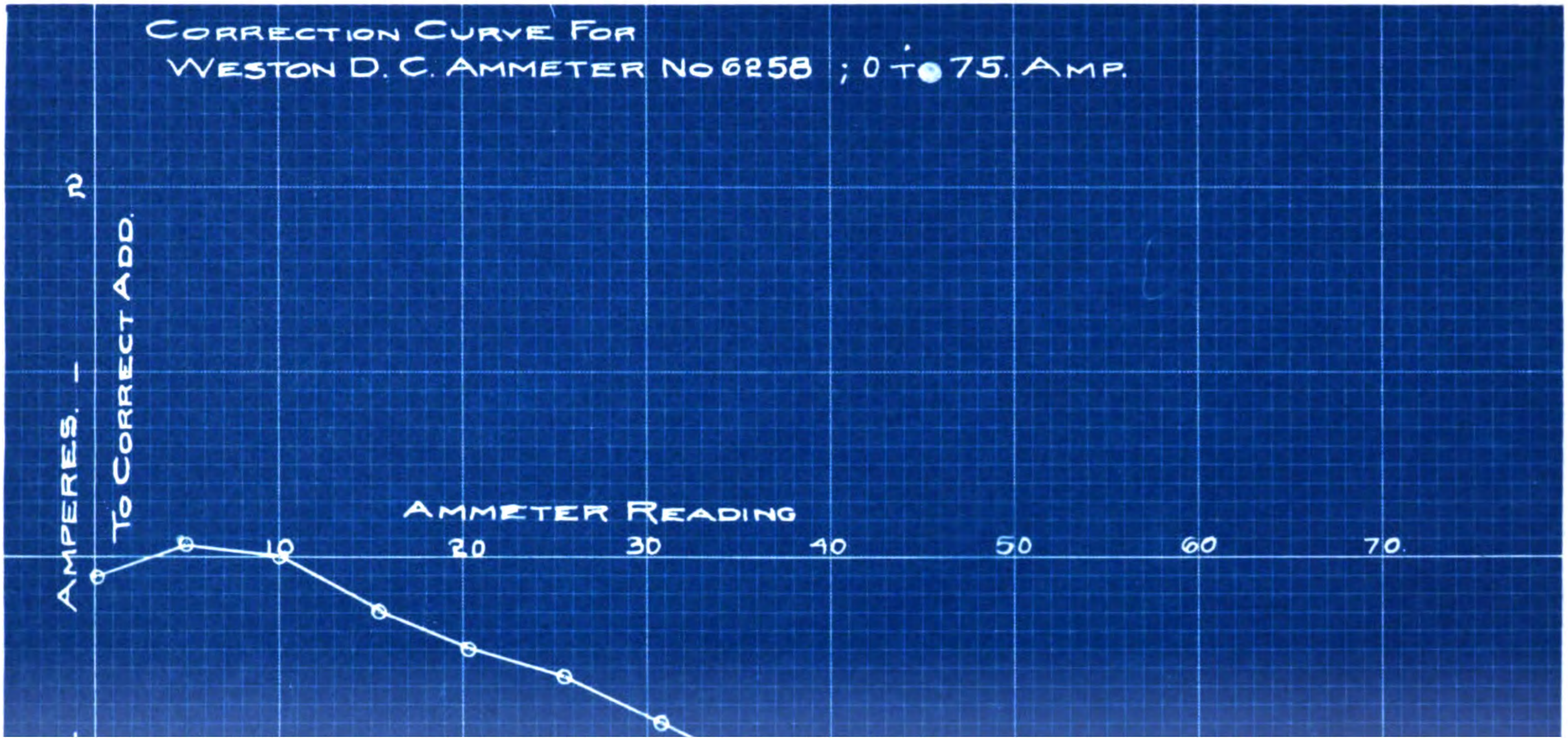

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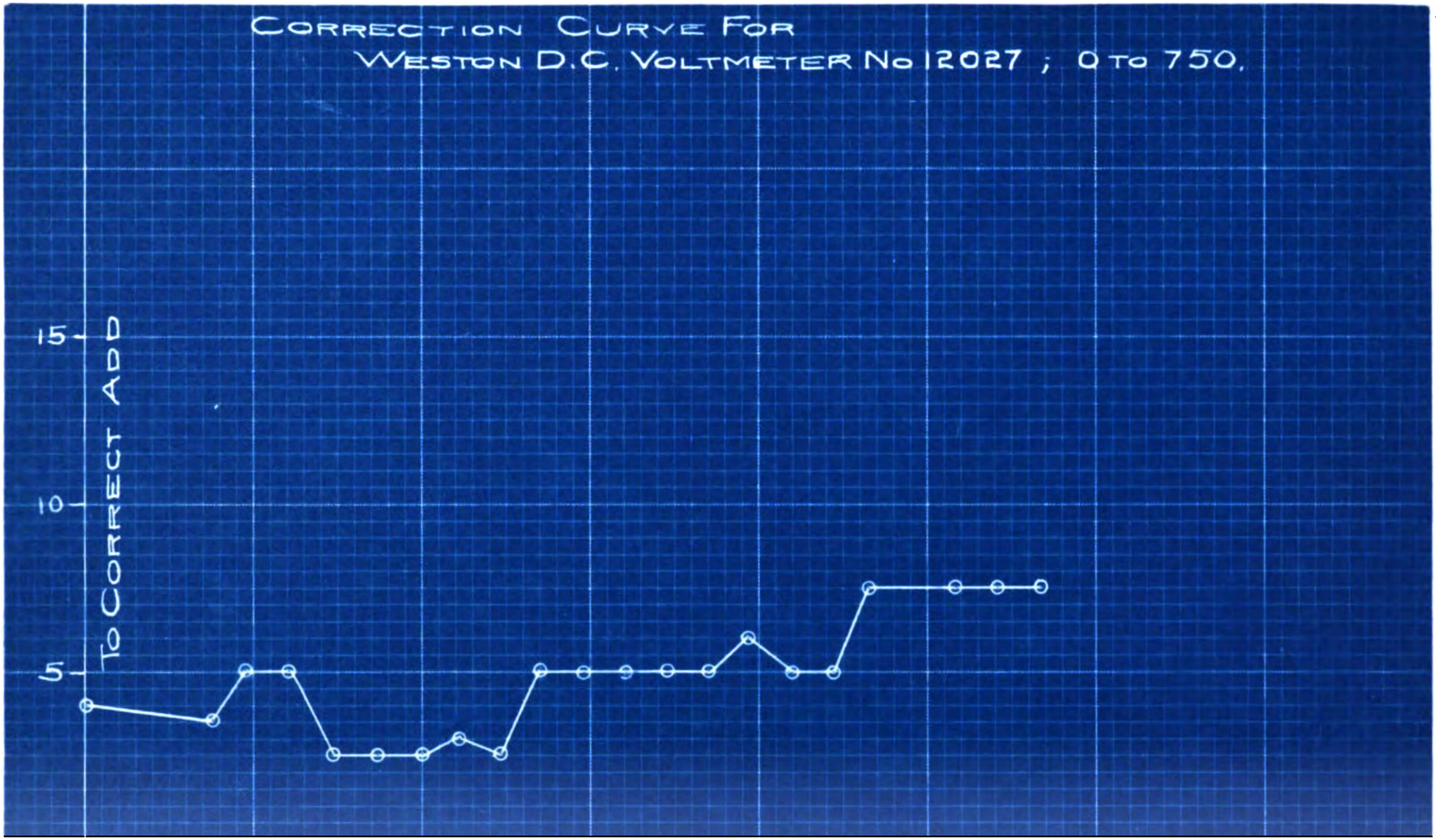

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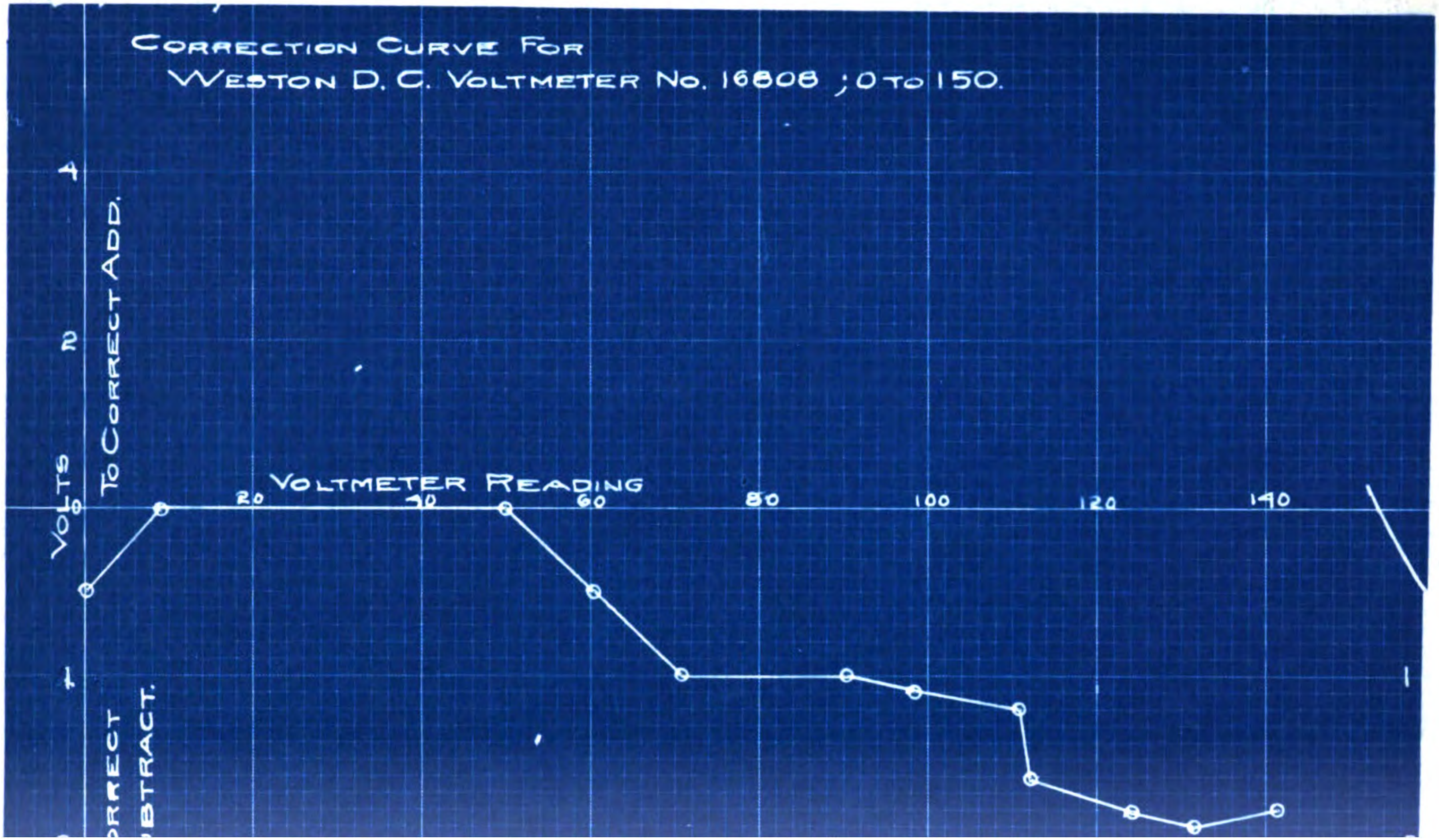

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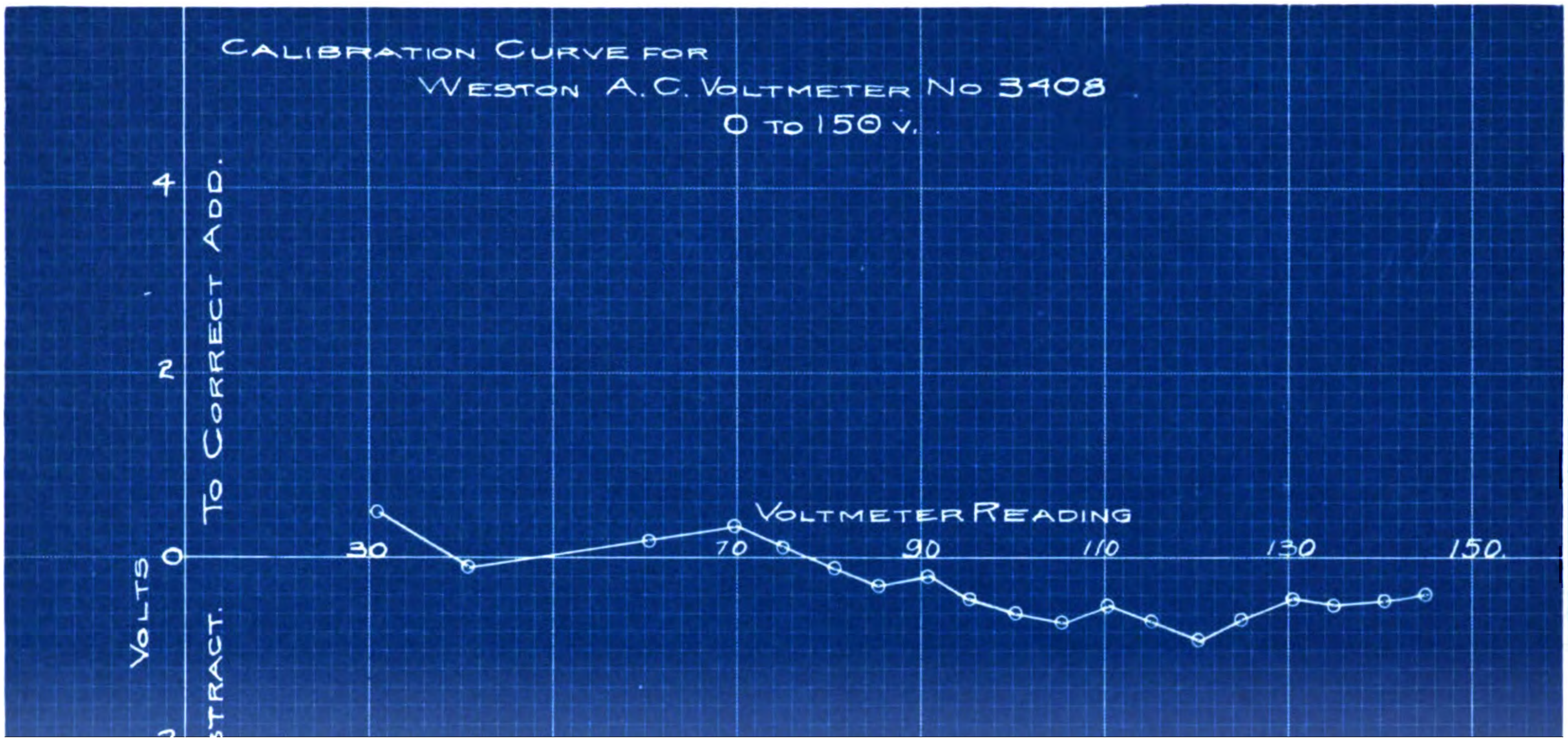

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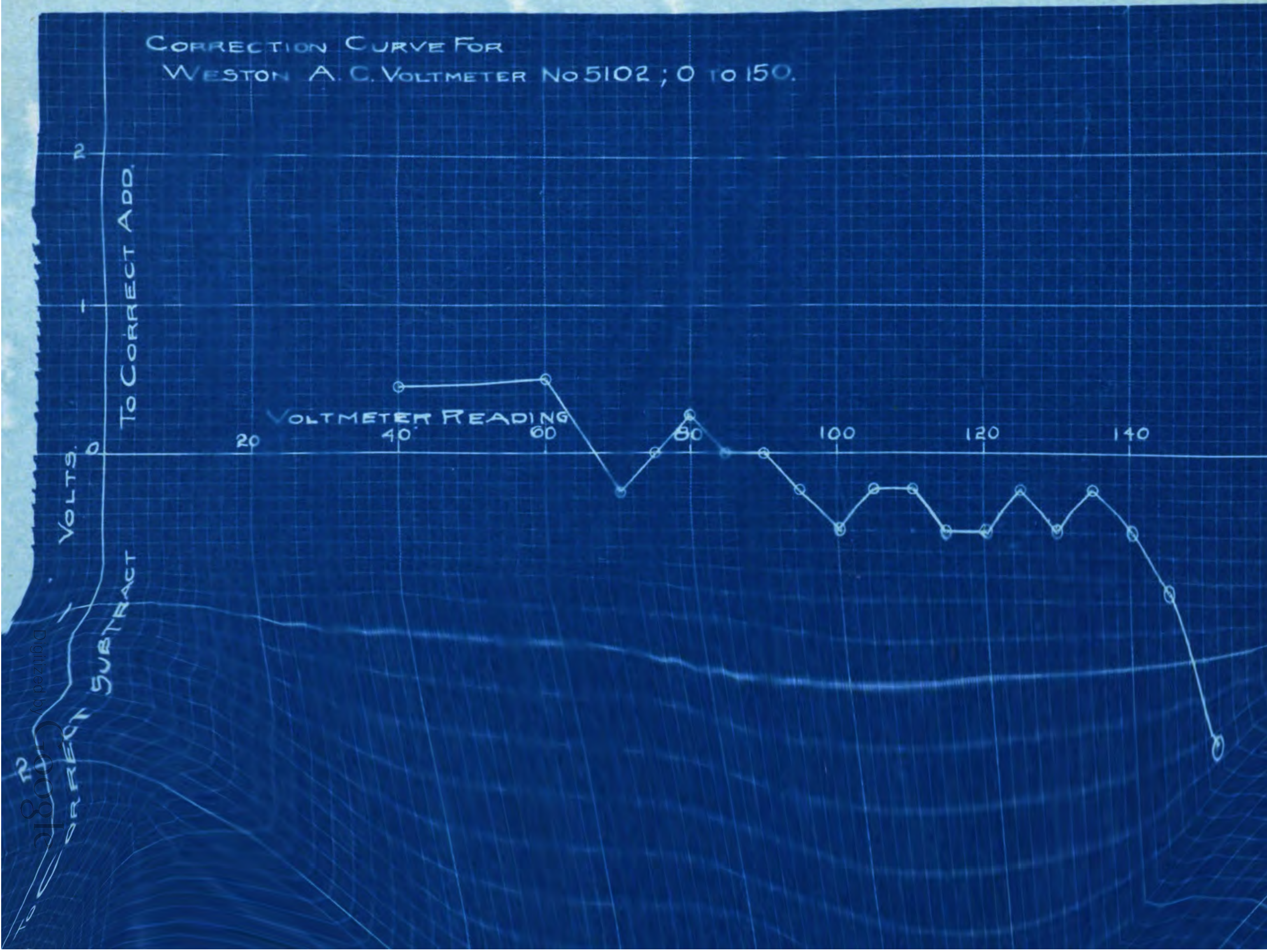

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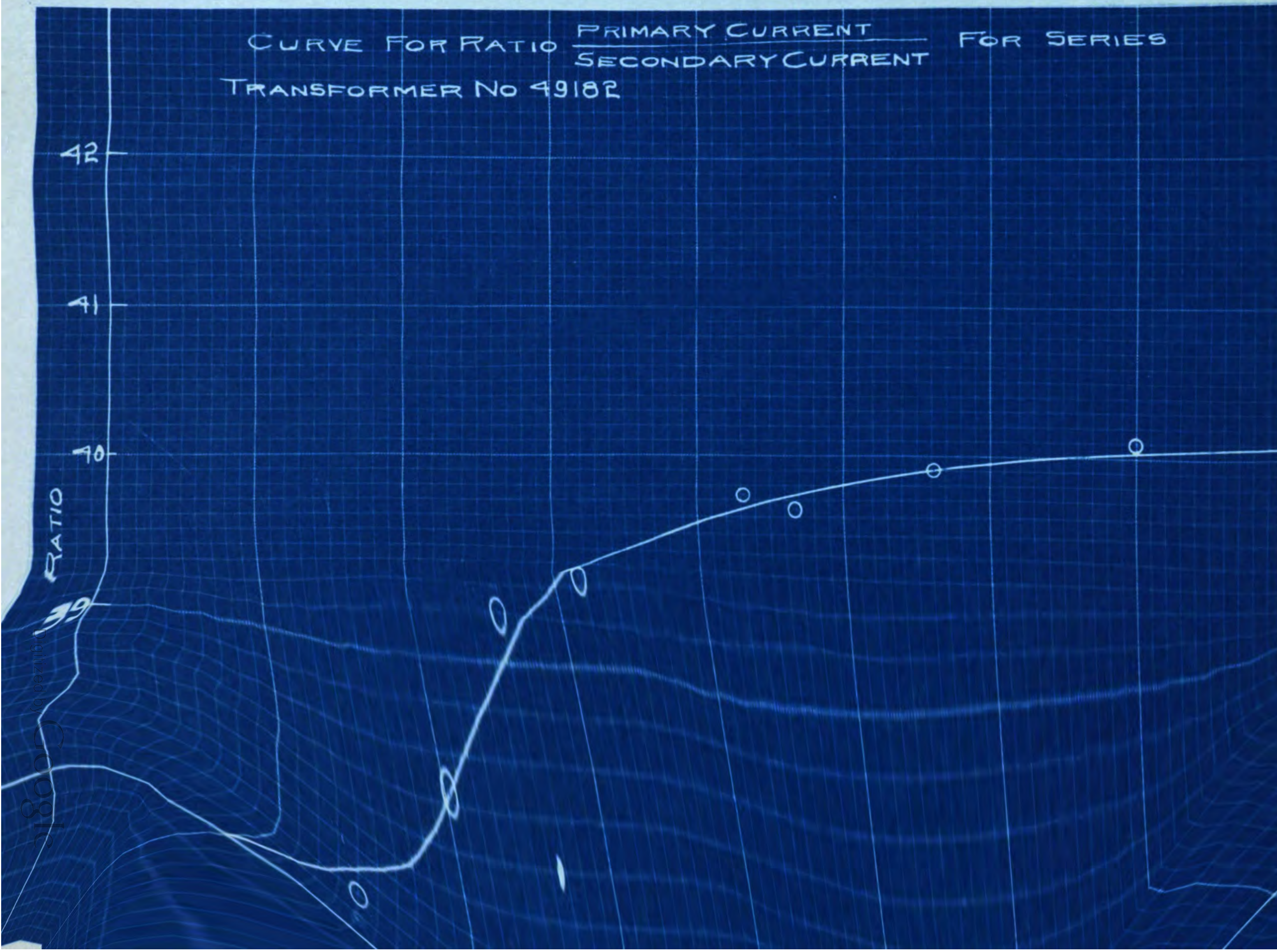
CURVE FOR RATIO PRIMARY CURRENT / SECONDARY CURRENT FOR SERIES
TRANSFORMER No 49182
42
41
40
39
RATIO

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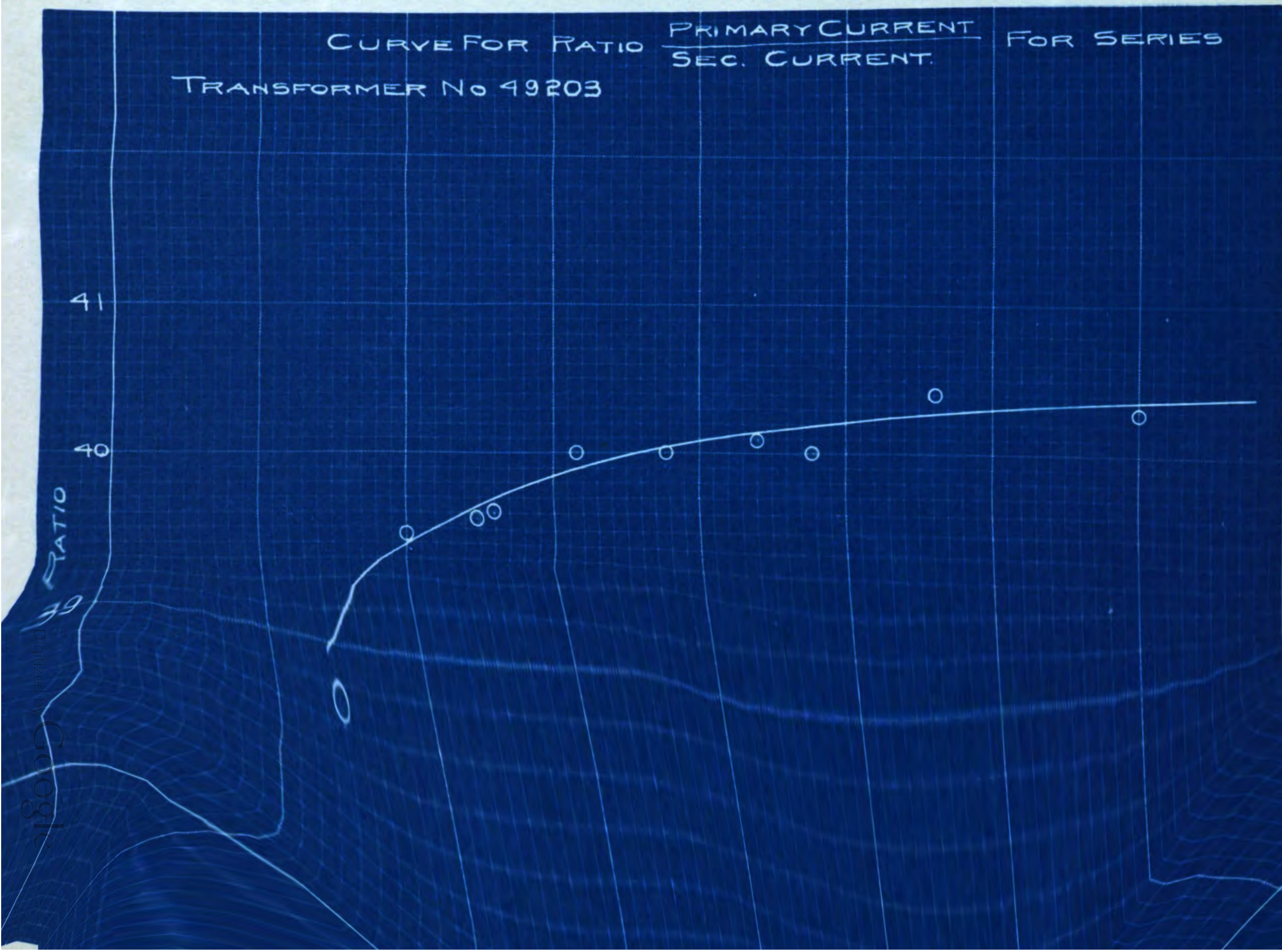

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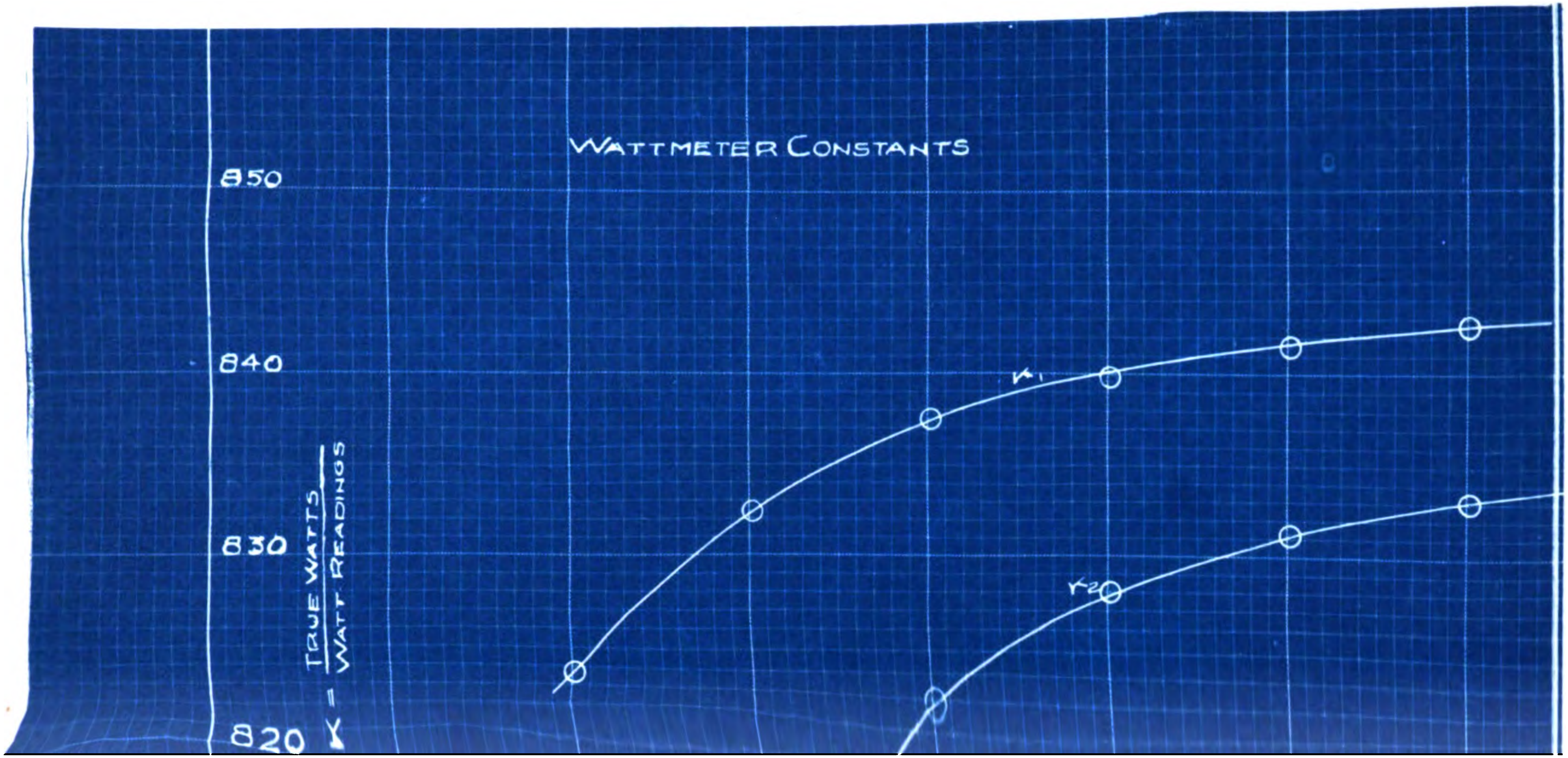

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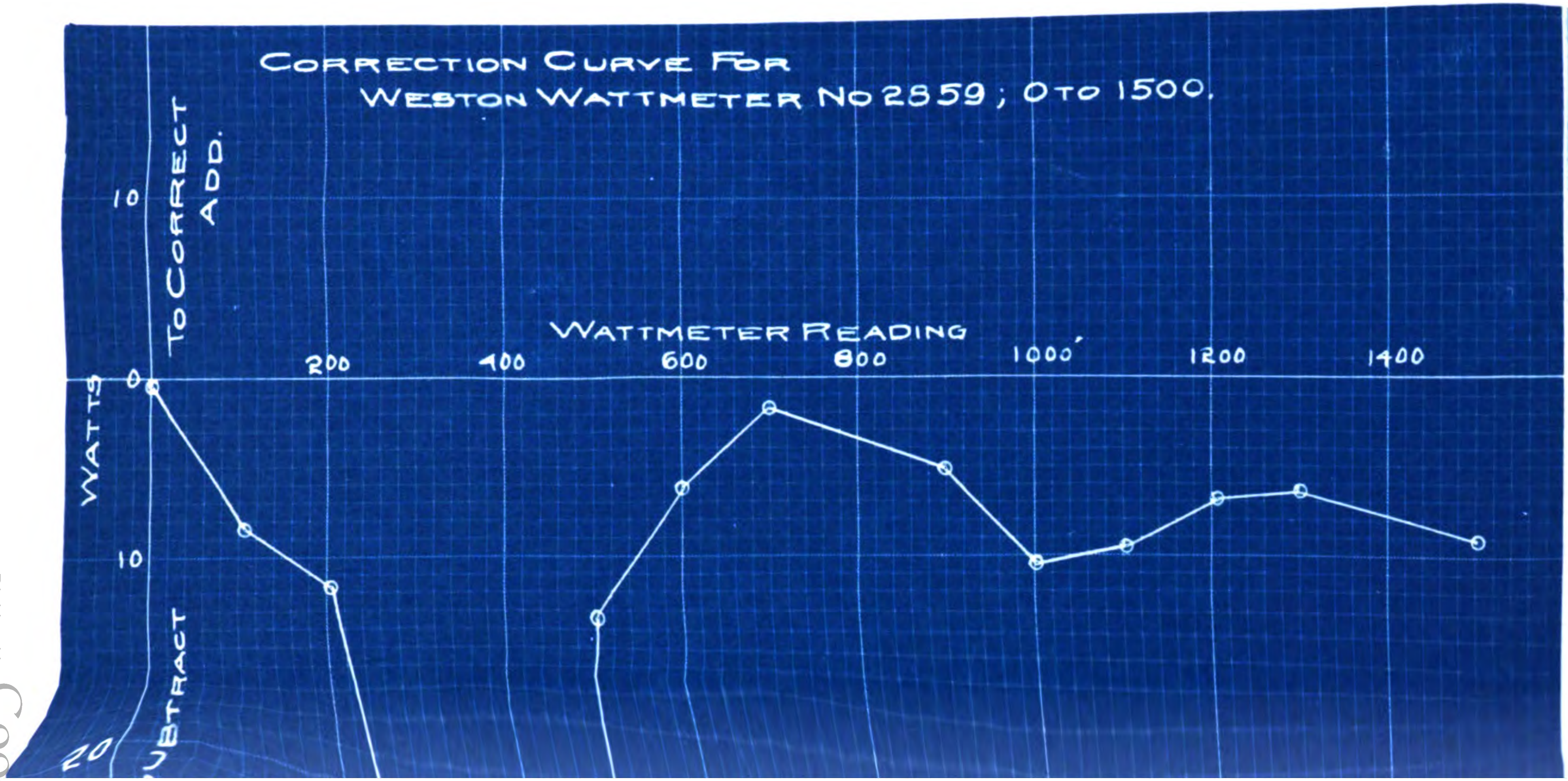

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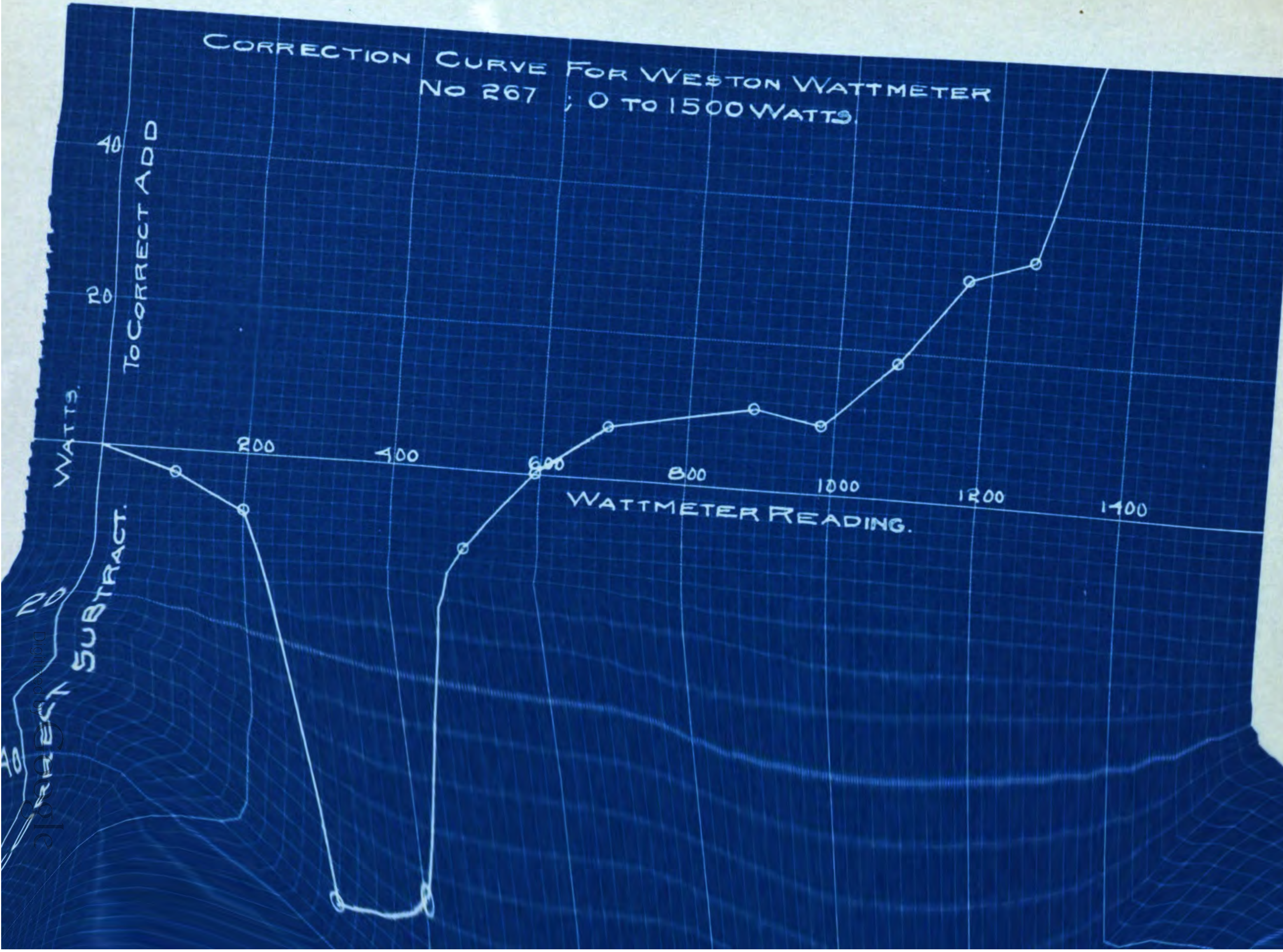

CORRECTION CURVE FOR WESTON WATTMETER
No 267 ; 0 TO 1500 WATTS.
40
20
TO CORRECT ADD
WATTS.
TO CORRECT SUBTRACT.
20
200
400
600
800
1000
1200
1400
WATTMETER READING.

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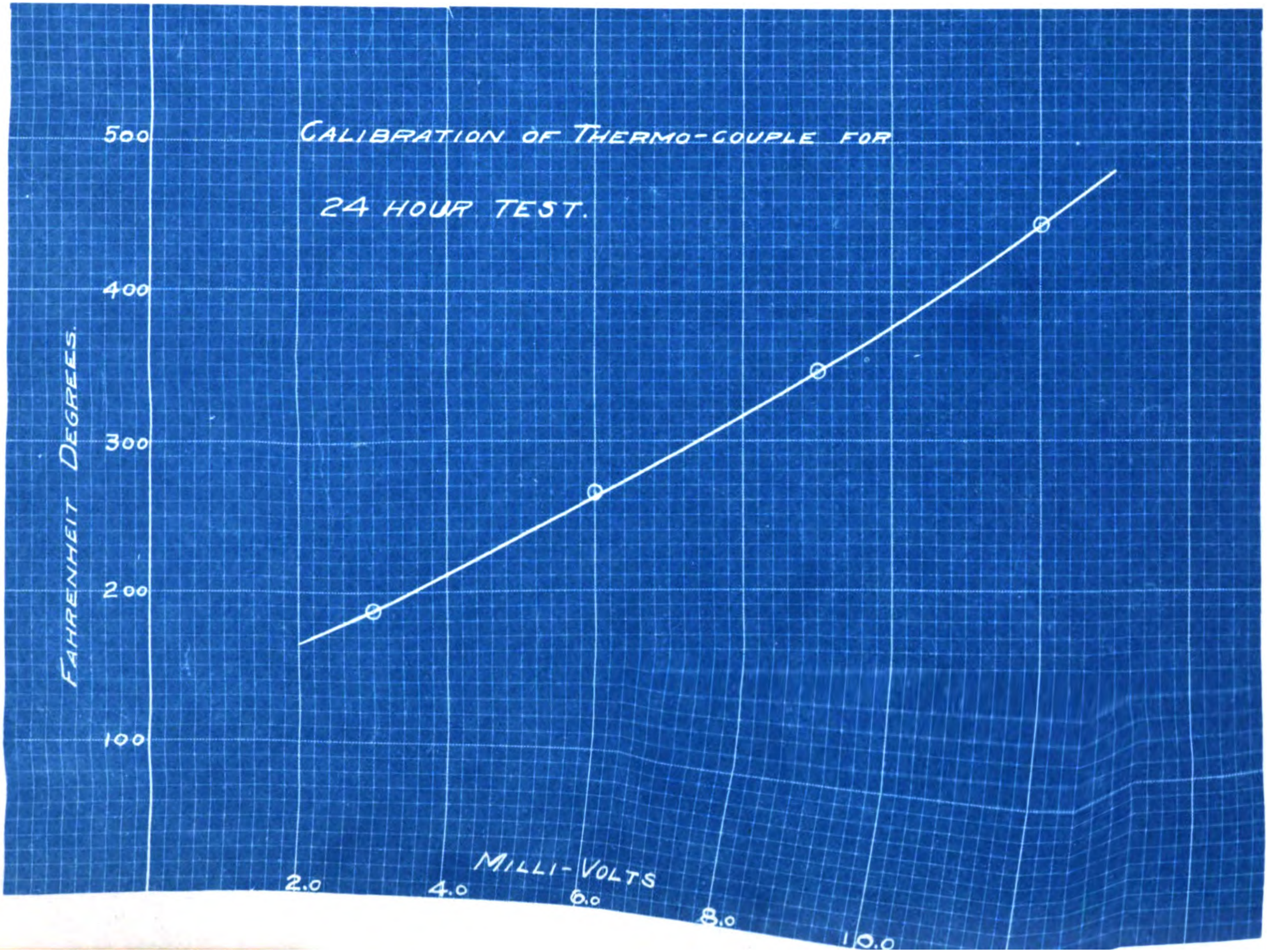

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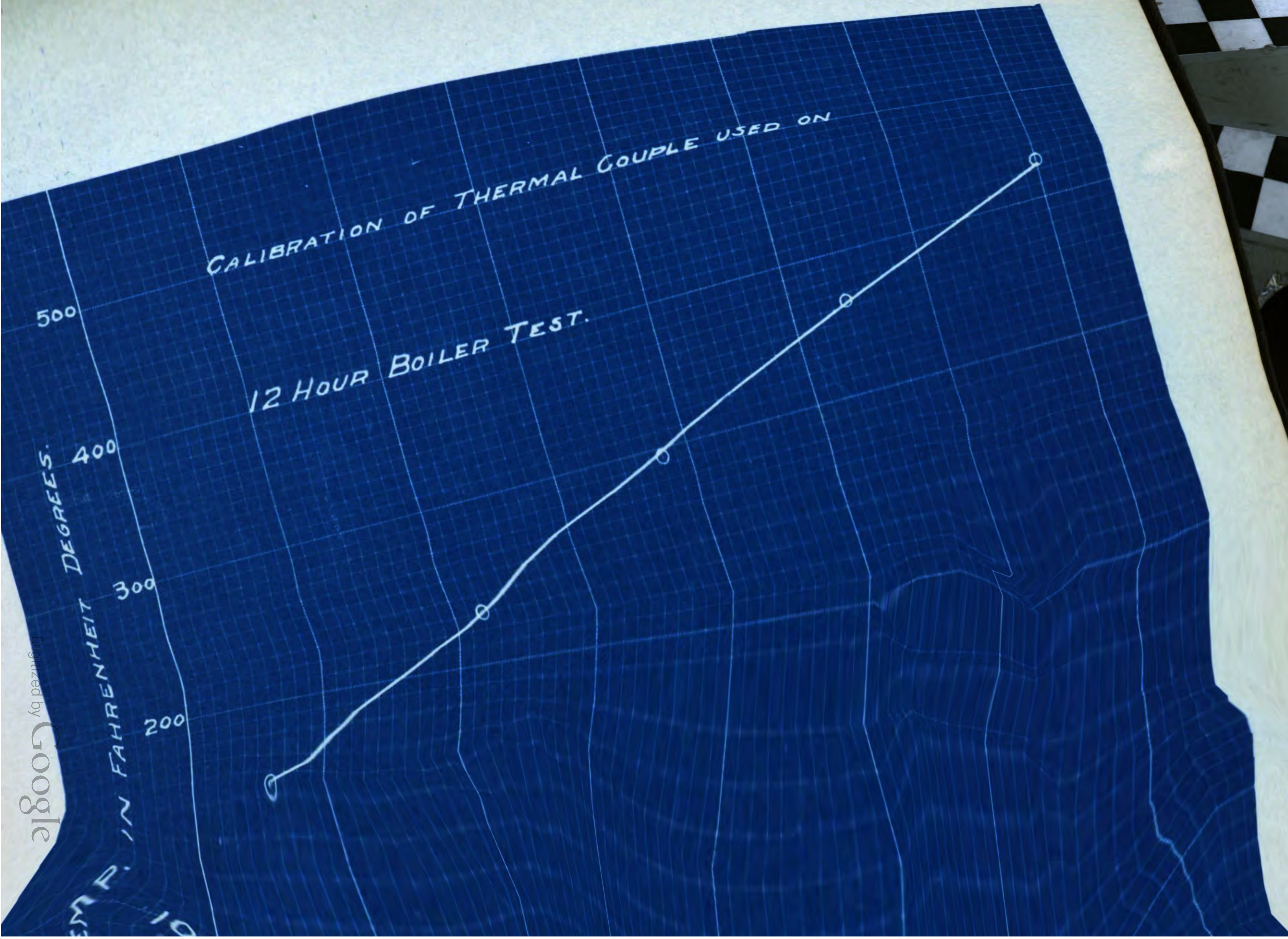

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Calibration of Potential Transformers by the Lamp Method

Method.

The high potential side of the potential transformer was connected across the high potential source. Twenty incandescent lamps were connected in series with a low reading ammeter in one of the high potential lines. The source of potential consisted of a step-up transformer with a maximum transformer ratio of 500 to 1 and a minimum of 25 to 1. By varying the resistance in the primary circuit, the primary impressed voltage could be varied between about 40 and 110 volts, and by properly operation the step-up transformer any voltage between 1000 volts and 55000 volts could be derived on the high potential side.

An accurately calibrated voltmeter and the one used on the same transformer during the test was used to read the voltage on the low potential side of the potential transformer and in order to exactly duplicate test conditions, the pressure coils of the wattmeter used on the test were also connected across the terminals on the low side of the potential transformer.

The current through the ammeter and lamps was kept constant throughout the calibration and the voltage

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across the low potential side was read successively for 20, 19, 18, 17 and 16 lamps in series in the high potential circuit. Then the voltage drop across each lamp taken separately at the above constant current was obtained from an accurately calibrated voltmeter. This gave sufficient data for the calculation of the ratio of transformation for the potential transformer.

Discussion of Results.

The chief difficulty encountered, in determining the transformer ratio by this method, is due to the fact that the current through the lamps can not be kept the same, because an ammeter is not sensitive enough to note small variations in current. The current could be kept more constant by the use of a comparator or a sensitive Kelvin Balance, and the method could be improved upon by the use of fewer lamps of higher voltage. On the whole, this method is too loose for accurate results, as shown by the calibration under consideration where in one calibration the variation in the ratio from the average ratio was about 1.8 per cent.

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DETERMINATION OF TRUE VOLTAGES ACROSS EACH LAMP TAKEN SEPARATELY AT A CURRENT OF 0.54 AMPERES.

Number of Lamp	Voltage across Lamp
1	112.43
2	121.50
3	119.60
4	112.53
5	114.60
6	134.65
7	127.60
8	116.30
9	111.46
10	120.71
11	128.00
12	113.80
13	121.90
14	118.50
15	117.30
16	122.32
17	111.56
18	140.98
19	138.78
20	146.13

Total 2450.65

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CALIBRATION OF POTENTIAL TRANSFORMER NO. 302723
CONSTANT CURRENT = 0.54 AMPERES.

Primary Volts	Secondary Volts	Condition of Lamps	Transformer Ratio
2450.65	123.72	All in	19.809
2304.52	112.60	#20 out	20.466
2165.74	107.72	#19 out	20.105
2024.76	98.92	#18 out	20.469
1913.20	95.06	#17 out	20.126
1790.88	89.28	#16 out	20.059
			20.172 = Average

CALIBRATION OF POTENTIAL TRANSFORMER NO. 302721
CONSTANT CURRENT = 0.54 AMPERES.

Primary Volts	Secondary Volts	Condition of Lamps	Transformer Ratio
2450.65	126.46	All in	19.378
2304.52	114.40	#20 out	20.144
2165.74	106.55	#19 out	20.326
2024.76	101.60	#18 out	19.928
1913.20	95.12	#17 out	20.113
1740.88	89.20	#16 out	20.077
			19.994 = Average

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Calibration of Potential Transformers.

Method.

In order to find the constant of the Electro-Static voltmeter it was necessary to obtain direct current. A small 1000 volt direct current generator served as the source and any desired voltage up to a maximum of about 1000 could be obtained. The constant was obtained by a direct comparison of the Electro-Static voltmeter deflection and standard voltmeter in the formula $KD = V^2$ in which $V =$ voltage, $D =$ deflection and $K =$ constant to be determined.

To calibrate the potential transformer, connections were made as shown in the accompanying print. It was found that the two transformer coils connected in series had the same number of turns so the Electro-Static voltmeter as connected gave one-half of the voltage impressed across the potential transformer under calibration.

The pressure coils of the wattmeter used on the test were connected as shown in the diagram, to reproduce actual test conditions, for it was found that an appreciable difference in the ratio of transformation resulted when the wattmeter pressure coils were cut out.

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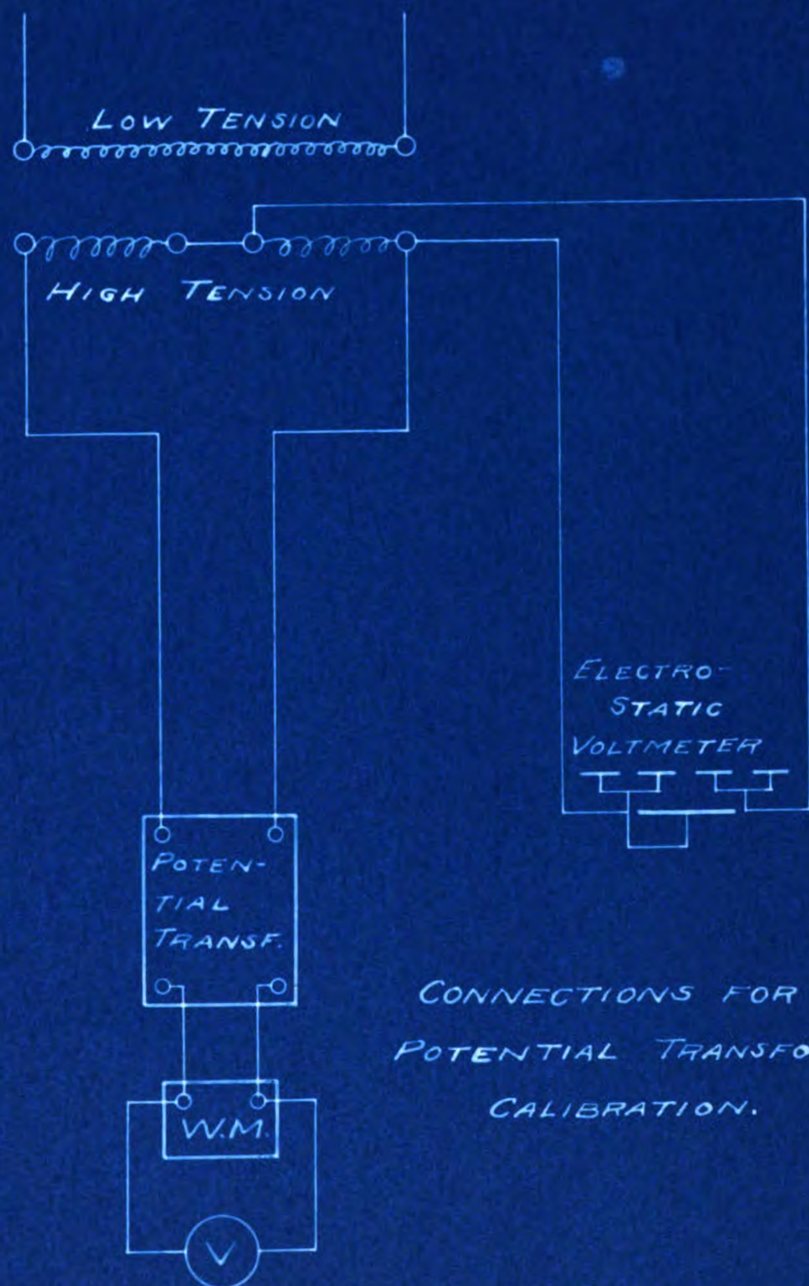

CONNECTIONS FOR
POTENTIAL TRANSFORMER
CALIBRATION.

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DETERMINATION OF CONSTANT OF ELECTRO-STATIC VOLTMETER
TO BE USED IN CALIBRATION OF POTENTIAL TRANSFORMER.

Standard Voltmeter Reading	Multiplier	Electro-Static Voltmeter Deflection	Constant of Electro-Static Voltmeter
76.5	6.829	1.95	140003
84.4		2.38	139241
93.7		2.93	139782
105.2		3.70	139525
128.3		5.50	139618
148.6		7.37	139,758

Average value of K = 139,654
$V^2 = KD$ where V = Voltage, D = Deflection.
Greatest variation of any constant from average constant = .296 of 1%
Calibration of Potential Transformer #302721

Deflection of Electro-Sta: Voltmeter	Primary Voltage Divided by 2	Primary Voltage	Voltage on Transformer Secondary	Ratio of Transformation
4.55	796.9	1593.8	76.4	20.862
5.45	872.4	1744.8	83.85	20.811
6.15	926.8	1853.6	89.0	20.822
7.075	994.0	1988.0	95.5	20.818
8.50	1089.5	2179.0	104.95	20.811
9.95	1178.1	2356.2	113.55	20.751
11.85	1286.5	2573.0	123.7	20.800
14.25	1410.3	2820.6	135.8	20.77

Average Ratio of transformation = 20.806
Greatest variation of any ratio from average ratio = .172 of 1%.

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CALIBRATION OF POTENTIAL TRANSFORMER NO. 302723.

Deflection of Electro-stat. Voltmeter	Primary Voltage Divided by 2	Primary Voltage	Voltage on Transformer Secondary	Ratio of Transformation
3.7	718.85	1437.70	68.90	20.866
5.37	865.98	1731.96	82.95	20.880
6.50	952.75	1905.50	91.30	20.868
8.10	1063.47	2126.94	101.85	20.876
9.98	1180.57	2361.14	112.70	20.859
11.95	1291.85	2583.70	124.0	20.885
14.13	1404.74	2809.48	133.8	20.960

Average Ratio of transformation = 20.885
Greatest variation of any ratio from average ratio = .36 of 1%.

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Discussion.

This method of transformer calibration proved very successful and the results were used in working up the data on the 24 hour turbine test. The principal advantage in this method of calibration is that all results can be referred right back to a standard instrument.

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Approved by F. W. Hicks.

Instructor in Experimental
Engineering.

June 17, 1909.

M C Beebe
Prof. Elec. Eng.

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